Final

Environmental Review for United States Air Force Operational Capability Enhancement in Australia

Headquarters Pacific Air Forces
Joint Base Pearl Harbor-Hickam, Hawaii

15 May 2013

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14. ABSTRACT

HQ PACAF proposes to establish new and increased combined exercises and interoperability at Royal Australian Air Force (RAAF) Bases Darwin and Tindal, located in the Northern Territory of Australia. This ER provides environmental analysis and documentation for these activities outside of the United States. The ER was prepared in accordance with Executive Order 12114, Environmental Effects Abroad of Major federal Actions Department of Defense Directive (DoDD) 6050.7, Environmental Effects Abroad of Major Department of Defense Actions, Title 32 of the Code of Federal Regulations (CFR) Parts 187 and 989, and applicable international agreements between the U.S. government and the government of Australia. This ER includes a statement of actions to be taken; identification of the important environmental issues involved; aspects of the actions taken or to be taken by the USAF that minimize the impact on the environment; and actions known to have been taken or planned to be taken by the government of any participating and affected foreign nations that may affect environmental considerations.

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Cover Sheet

Final Environmental Review

United States Air Force

Operational Capability Enhancement in Australia

Responsible Agencies: Headquarters Pacific Air Forces (HQ PACAF)

Proposed Action: Enhance United States Air Force (USAF) capabilities in the Northern Territory of Australia.

For more information, contact: William H. Bushman, USAF NEPA Center/ PACAF Program Manager, 210-395-8448

Report Designation: Final Environmental Review (ER)

Abstract: HQ PACAF proposes to establish new and increased combined exercises and interoperability at Royal Australian Air Force (RAAF) Bases Darwin and Tindal, located in the Northern Territory of Australia. This ER provides environmental analysis and documentation for these activities outside of the United States. The ER was prepared in accordance with Executive Order 12114, *Environmental Effects Abroad of Major federal Actions*, Department of Defense Directive (DoDD) 6050.7, *Environmental Effects Abroad of Major Department of Defense Actions,* Title 32 of the Code of Federal Regulations (CFR) Parts 187 and 989, and applicable international agreements between the U.S. government and the government of Australia. This ER includes a statement of actions to be taken; identification of the important environmental issues involved; aspects of the actions taken or to be taken by the USAF that minimize the impact on the environment; and actions known to have been taken or planned to be taken by the government of any participating and affected foreign nations that may affect environmental considerations.

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Executive Summary

Introduction

The United States (U.S.) Pacific Air Forces (PACAF) and the Air Force Civil Engineering Center (AFCEC) prepared this Environmental Review (ER) in accordance with Executive Order (EO) 12114 *Environmental Effects Abroad of Major Federal Actions*, Department of Defense Directive (DoDD) 6050.7 *Environmental Effects Abroad of Major Department of Defense Actions,* and applicable international agreements between the U.S. government and government of Australia. The purpose of the ER is to survey the important environmental issues involved with the proposed action and identify necessary impact minimization measures to be taken by the U.S. Air Force (USAF).

Proposed Action

The Proposed Action is to increase USAF use of Royal Australian Air Force (RAAF) Bases Darwin and Tindal for aircraft training, interoperability exercises, and humanitarian missions. RAAF Bases Darwin and Tindal are located in the Northern Territory of Australia. PACAF initially proposes to use existing airfield, refueling, and aerospace ground equipment (AGE) storage at the RAAF bases. The USAF will require access to adequate runways, taxiways, aprons, jet fuel receipt/ delivery/ storage, maintenance warehouses, billeting capacity, and other supporting infrastructure (communications, medical, and security) to support training and interoperability exercises. PACAF also proposes long-term capital improvements at RAAF Bases Darwin and Tindal, contingent upon appropriation and authorization from the U.S. Congress. Such improvements will support periodic training exercises, and a wide spectrum of missions. Approximately 280 U.S. airmen will deploy to RAAF Base Darwin and 340 to RAAF Base Tindal during the training exercises. The aircraft to be used during the training exercises include fighters, bombers, and tankers at both installations. Additionally, unmanned aerial vehicles (UAVs) will be used at RAAF Base Tindal.

RAAF Bases Darwin and Tindal Important Environmental Issues

This ER evaluated the potential environmental effects of the Proposed Action for the following environmental resources: utilities, water quality, hazardous materials and waste, transportation, air quality and greenhouse gases, biological resources, wildfire, heritage, health and safety, and noise. The potential effects to these resources were evaluated relative to the existing environment. For each environmental resource or issue, anticipated direct and indirect effects were assessed, considering both short-term and long-term project effects. Table ES-1 summarizes the potential environmental issues and necessary impact minimization measure for each resource analyzed.

Table ES-1
Impact Minimization Summary Table
PACAF Australia ER

Environmental Issue	Impact Minimization Measure or Best Management Practices (BMPs)
RAAF Base Darwin	
Utilities	
The base is currently operating at the edge of its current electrical capacity.	Backup electrical capacity will be supplied during exercises, if necessary.
Solid waste management and recycling are important issues to the RAAF.	When planning for exercises, USAF personnel will coordinate with the Estate Manager for additional solid waste trucks. Recycling will be a priority.
Water Quality	
Stormwater runoff could impact Rapid Creek.	Stormwater BMPs will be included in the design of any proposed capital improvement facilities.
Fuel spills could enter Rapid Creek.	BMPs will be implemented to prevent spills from entering Rapid Creek and USAF units will implement spill prevention measures.
Hazardous Materials and Hazardous Waste	
Potential discovery of contaminated landfills during construction.	If a landfill is discovered, operations will cease and the RAAF will be contacted immediately and allowed to manage the cleanup.
Use of hazardous materials and waste generation.	All USAF activities will follow established Department of Defense (DoD) guidelines.
The use of hydrazine is a specific concern to the RAAF Defence Support Group (DSG).	Hydrazine will be handled in accordance with established neutralization procedures (Technical Order 1F-16C-2-49GS-00-1).
Transportation	
Increased traffic could negatively affect the installation's transportation infrastructure.	USAF personnel will be transported by bus during the joint training exercises when possible. The use of personal vehicles will be limited.
Air Quality and Greenhouse Gases	
Increased dust emissions during construction activities.	Standard dust control BMPs such as watering bare ground will be implemented during construction.
Biological Resources	
Impacts to protected Australian wildlife.	Airmen and construction contractors will be informed of the protected status of all Australian vertebrates and advised to avoid harm to any animals.
Potential introduction of organisms exotic to Australia.	USAF will conform to the policy and procedures agreed on during the 2013 Talisman Sabre exercises.
Heritage	
Disturbance to a previously unidentified archaeological site.	If artifacts are discovered, operations will cease and RAAF DSG personnel will be contacted.

Table ES-1
Impact Minimization Summary Table
PACAF Australia ER

Environmental Issue	Impact Minimization Measure or Best Management Practices (BMPs)
A negative effect on the historic character of RAAF Base Darwin.	New facilities will follow the RAAF Base Darwin Master Plan (Woods Bagot, 2009).
Health and Safety	
Potential wildlife strikes by aircraft.	Any incidents of wildlife strikes by aircraft will be reported to the RAAF DSG.
Disease-carrying insects may be present during exercises and construction.	Precautions will be taken to avoid being bitten as outlined by the Northern Territory Department of Health.
Inadvertent discovery of unexploded ordinance (UXO) during construction.	Any discovery of UXO will result in ceasing operations and notification of the RAAF DSG.
Noise	
Increased noise to surrounding community.	Aircraft will be operated in compliance with aircraft operating and local noise abatement procedures. Current rules restrict fighters from departing after 10 PM.
RAAF Base Tindal	
Utilities	
The base is currently operating at the edge of its current electrical capacity.	Backup electrical capacity will be supplied during exercises, if necessary.
Solid waste management and recycling are important issues to the RAAF.	When planning for exercises, USAF personnel will coordinate with the Estate Manager for additional solid waste trucks. Recycling will be a priority.
Water Quality	
Stormwater runoff could impact Tindal Creek.	Stormwater BMPs will be included in the design of any capital improvement facilities.
Fuel spills could enter Tindal Creek or groundwater.	BMPs will be implemented to prevent spills from entering Tindal Creek or sinkholes and USAF personnel will implement spill protection measures.
Hazardous Materials and Hazardous Waste	
Potential discovery of contaminated areas during operations.	If a contaminated area is discovered, the RAAF will be contacted immediately and allowed to manage the cleanup.
Use of hazardous materials and waste generation.	All USAF activities will follow established U.S. DoD guidelines.
The use of hydrazine is a specific concern to the RAAF DSG.	Hydrazine will be handled in accordance with established neutralization procedures (Technical Order 1F-16C-2-49GS-00-1).
Transportation	
Increased traffic could negatively affect the installation's transportation infrastructure.	USAF personnel will be transported by bus during the joint training exercises when possible. The use of personal vehicles will be limited.

Table ES-1
Impact Minimization Summary Table
PACAF Australia ER

Environmental Issue	Impact Minimization Measure or Best Management Practices (BMPs)
Air Quality and Greenhouse Gases	
Increased dust emissions during construction activities.	Standard dust control BMPs, such as watering bare ground, will be implemented during construction.
Biological Resources	
Impacts to protected Australian wildlife.	Airmen and construction contractors will be informed of the protected status of all Australian vertebrates and advised to avoid harm to any animals. If a sensitive species is identified by RAAF personnel in the vicinity of the Proposed Action, operations will cease and measures will be taken under the guidance of RAAF DSG personnel to avoid harming the organism.
Potential introduction of organisms exotic to Australia.	USAF will conform to the policy and procedures agreed on during the 2013 Talisman Sabre exercises.
Heritage	
Disturbance to a previously unidentified archaeological site.	If artifacts are discovered, operations will cease and RAAF DSG personnel will be contacted.
Health and Safety	
Potential wildlife strikes by aircraft.	Any incidents of wildlife strikes by aircraft will be reported to the RAAF DSG.
Disease-carrying insects may be present during exercises and construction.	Precautions will be taken to avoid being bitten as outlined by the Northern Territory Department of Health.
Inadvertent discovery of UXO during construction.	Any discovery of UXO will result in ceasing operations and notification of the RAAF DSG.
Noise	
Increased noise to surrounding community.	Aircraft will be operated in compliance with aircraft operating and local noise abatement procedures. Current rules restrict fighters from departing after 10 PM.

Conclusion

In accordance with the DoDD 6050.7 and EO 12114, the findings in this ER verify the Proposed Action will have no significant impact on the quality of the natural or physical environment at RAAF Bases Darwin or Tindal.

SECTION 1.0

Introduction

This section describes the purpose and need for the Proposed Action, summarizes the scope of the Environmental Review (ER), and explains applicable regulatory requirements.

This ER has been prepared in accordance with U.S. Air Force (USAF or Air Force) obligations under Executive Order 12114, *Environmental Effects Abroad of Major federal Actions*; U.S. Department of Defense Directive (DoDD) 6050.7, *Environmental Effects Abroad of Major Department of Defense Actions* (which was formally promulgated and published at 32 CFR 187); USAF environmental planning regulations (32 CFR 989); and applicable international agreements between the United States (U.S.) government and the government of Australia.

1.1 Background

The U.S. has been a Pacific power for more than a century and U.S. economic and security interests are inextricably linked to the Asia-Pacific region (Department of Defense [DoD], 2010 and 2012). However, due to the vast distances of the Pacific and low density of U.S. basing and infrastructure, there is a premium on forward stationed and deployed U.S. forces. The U.S. DoD seeks to strengthen its Asia-Pacific alliances, augment its forward presence in the region (DoD, 2010), and rebalance toward the Asia-Pacific region (DoD, 2012).

On 16 November 2011, President Obama of the United States and Australian Prime Minister Gillard announced a plan to expand the U.S. military presence in Australia. During the announcement, Prime Minister Gillard agreed to greater access by U.S. military aircraft to Royal Australian Air Force (RAAF) facilities in Australia's Northern Territory. The purpose of the expanded presence of U.S. forces is to enhance U.S. and Australian interoperability, training, and response to challenges, including humanitarian assistance and disaster relief operations in the Asia-Pacific region (White House, 2011).

The U.S. and Australian militaries have trained and exercised together for more than 60 years under the Australia-New Zealand-U.S. alliance. The U.S. military and Australian Defence Force (ADF) have conducted major bilateral training exercises for decades, the two largest of which, Exercises Talisman Sabre and Pitch Black, take place in the Northern Territory, among other RAAF locations.

1.2 Purpose and Need for the Proposed Action

The U.S. Pacific Air Forces (PACAF) is planning to increase use of RAAF airfields located in the Northern Territory of Australia. The increased use of these airfields by the USAF will expand current RAAF-USAF interoperability and exercise capabilities, and develop stronger regional military-to-military training relationships. There is also a need for additional airfield capacity and access to training ranges across the U.S. Pacific Command (USPACOM) Area of Responsibility (AOR), including Northern Australia, to better provide

humanitarian assistance and disaster relief operations, as well as satisfy other joint and combined operational requirements.

1.3 Objectives of the Proposed Action

The objectives of the Proposed Action are:

- Increase interoperability between U.S. and Australian forces;
- Improve training and exercise opportunities between the USAF and RAAF; and
- Increase airfield capacity in the Northern Territory of Australia to support USAF-RAAF joint efforts.

1.4 Location of the Proposed Action

Under the Proposed Action, the USAF will increase its use of RAAF Bases Darwin and Tindal, both located in the Northern Territory of Australia.

RAAF Base Darwin encompasses approximately 3,212 acres (1,300 hectares) near the city of Darwin on the north-central coast of Australia (see **Figure 1-1**). Darwin International Airport (DIA) is co-located northwest of RAAF Base Darwin, and the combined RAAF Base/Airport site is identified as a Joint User Airport. Military and civil aircraft operations are coordinated by the Darwin Air Traffic Control tower, and the two entities share management of much of the airfield. RAAF Base Darwin is home to:

- No. 396 Expeditionary Combat Support Wing;
- No. 92 Wing Detachment Darwin - surveillance and response;
- No. 452 Squadron Headquarters;
- No. 452 Squadron Darwin Flight - air traffic control;
- No. 13 (City of Darwin) Squadron;
- No. 1 Airfield Operations Support Squadron Detachment Darwin - air movements;
- Darwin Area Health Centre; and
- No. 114 Mobile Control and Reporting Unit - radar operations.

RAAF Base Tindal covers approximately 30,146 acres (12,200 hectares) near the town of Katherine, about 198 miles (320 kilometers) south of Darwin (see **Figure 1-1**). RAAF Base Tindal is the primary tactical fighter base in the Northern Territory and hosts both Australian and foreign fighter squadrons for training exercises. The base lies adjacent to Stuart Highway, which provides direct access to both Katherine and Darwin. RAAF Base Tindal is home to:

- No. 75 Squadron - F/A-18 Hornet;
- No. 452 SQN Tindal Flight - air traffic control;
- No. 1 Combat Logistics Squadron;
- No. 322 Expeditionary Combat Support Squadron;
- No. 1 Air Terminal Squadron Detachment Tindal;
- No. 2 Expeditionary Health Squadron Detachment Tindal;
- No. 3 Control and Reporting Unit Detachment Tindal; and
- A detachment of the Army's North-West Mobile Force (NORFORCE).

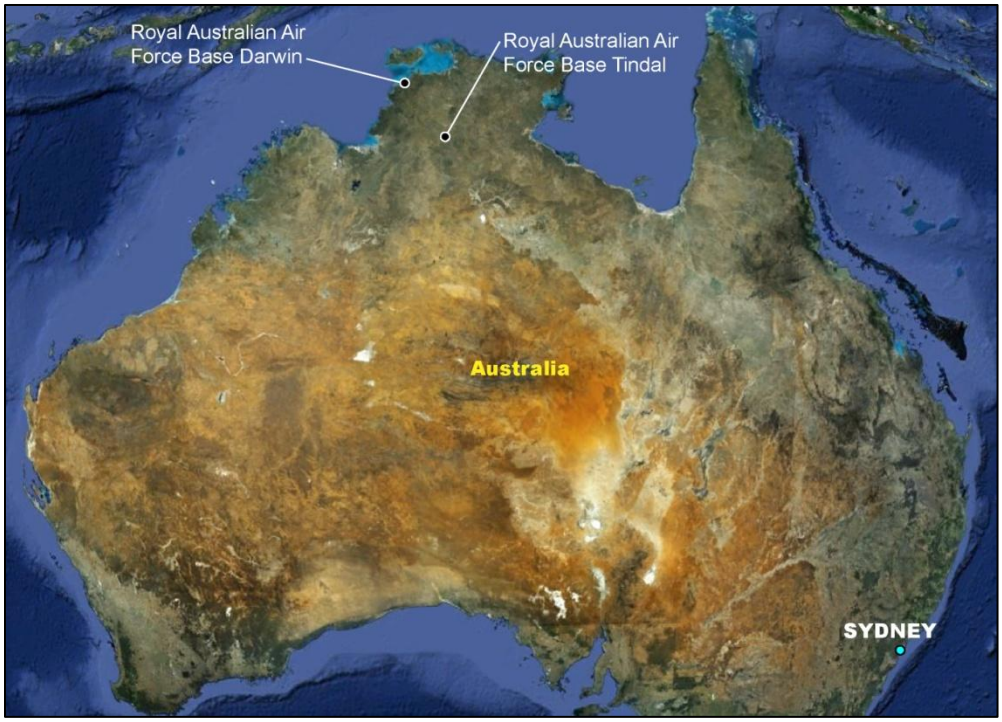


Figure 1-1
General Map of Proposed Action
PACAF Australia ER

1.5 Organization of the Environmental Review

This ER contains all of the required sections outlined in DoDD 6050.7. The document is organized into the following sections:

- ***Section 1.0, Introduction,*** provides background information about the Proposed Action, the purpose and need for the Proposed Action, and a brief description of how the document is organized.
- ***Section 2.0, Description of the Proposed Action,*** presents a detailed description of the Proposed Action.
- ***Section 3.0, RAAF Base Darwin Important Environmental Issues,*** provides a description of the existing conditions of the environmental resources potentially affected, and the potential impacts to those resources at RAAF Base Darwin. Additionally, actions that will minimize or ameliorate impacts of the Proposed Action on the environment are discussed.
- ***Section 4.0, RAAF Base Tindal Important Environmental Issues,*** provides a description of the existing conditions of the environmental resources potentially affected, and the potential impacts to those resources at RAAF Base Tindal. Additionally, actions that will minimize or ameliorate impacts of the Proposed Action on the environment are discussed.
- ***Section 5.0, Summary of Impact Minimization Measures,*** provides a summary of the actions taken by the USAF that ameliorate or minimize the impacts to the environment.

- ***Section 6.0, Contributing Actions,*** presents a statement of actions of participating and affected foreign governments that may affect environmental considerations.
- ***Section 7.0, Coordination,*** provides a list of agencies/individuals contacted for information in the preparation of this document.
- ***Section 8.0, List of Preparers,*** lists the names and qualifications of the document preparers.
- ***Section 9.0, Acronyms and Abbreviations,*** presents a list of acronyms and abbreviations used in this ER.
- ***Section 10.0, References,*** provides a listing of the references used in preparing this ER.
- ***Appendix A, Air Emission Calculations***, provides the calculations used to evaluate aircraft air emissions.
- ***Appendix B, Aircraft Noise Study***, details the modeling performed to calculate the aircraft noise impacts.

SECTION 2.0

Description of the Proposed Action

The Proposed Action is to increase USAF use of RAAF Bases Darwin and Tindal for aircraft training, interoperability exercises, and humanitarian missions. PACAF initially proposes to use existing airfield, refueling, and aerospace ground equipment (AGE) storage at the RAAF bases. The USAF will require access to adequate runways, taxiways, aprons, jet fuel receipt/ delivery/ storage, maintenance warehouses, billeting capacity, and other supporting infrastructure (communications, medical, and security) to support training and interoperability exercises.

PACAF also proposes long-term capital improvements at RAAF Bases Darwin and Tindal, contingent upon appropriation and authorization from the U.S. Congress. Such improvements will support periodic training deployments of a variety of USAF and joint/combined platforms, and a wide spectrum of missions.

Aircraft used during the proposed training exercises at RAAF Base Darwin will include a combination of bombers, tankers, and fighters, while at RAAF Base Tindal, the proposed training exercises will involve the use of bombers, tankers, fighters, and unmanned aerial vehicles (UAVs). Most of these aircraft have operated at both bases in the past, with the exception of bombers and UAVs at RAAF Base Tindal.

2.1 Capital Improvements

Airfield resources at RAAF Bases Darwin and Tindal will be upgraded to facilitate use by USAF aircraft. The following is a description of the proposed capital improvement activities at each base.

2.1.1 RAAF Base Darwin

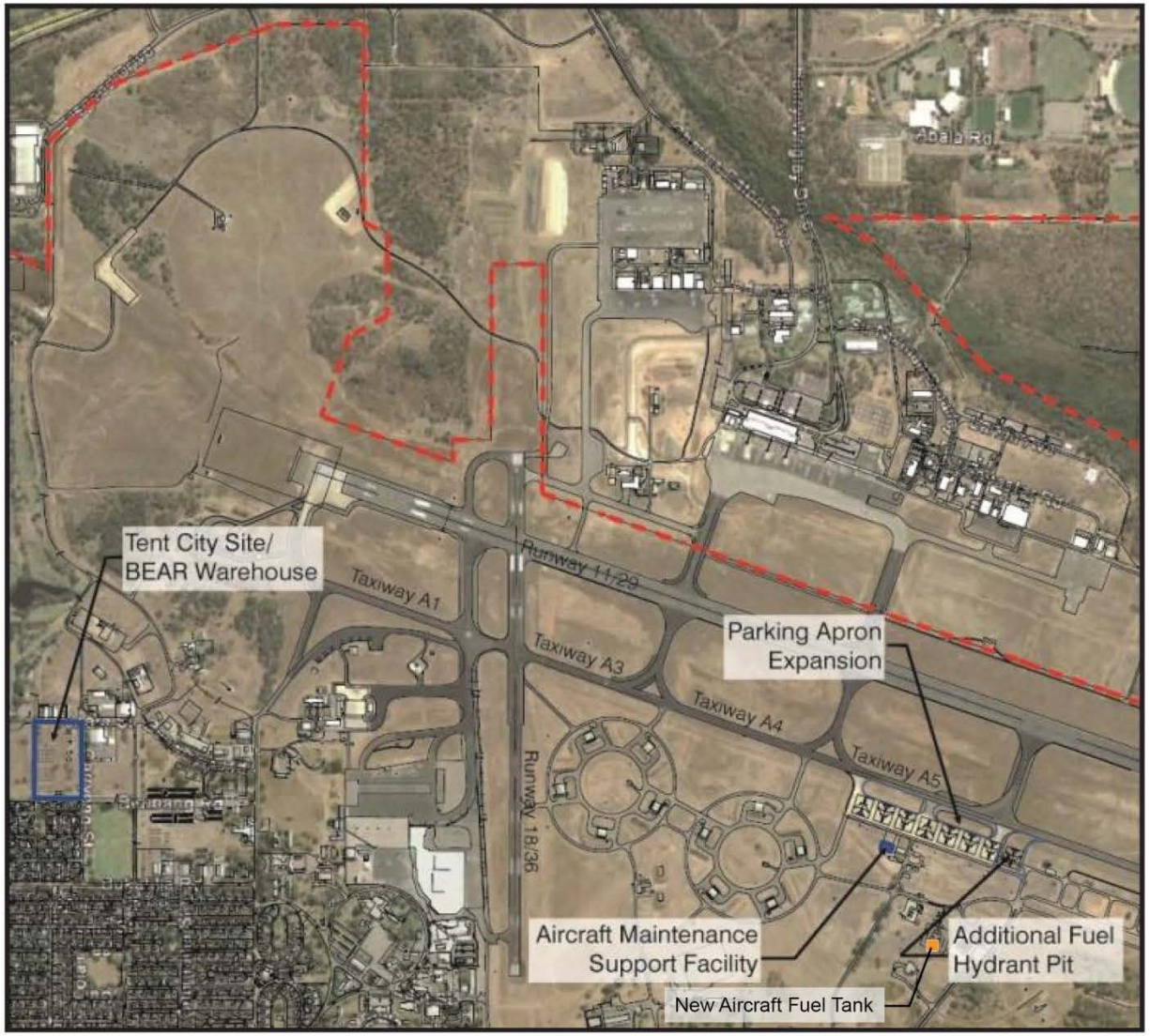
In order to accommodate USAF aircraft operations, the following proposed capital improvements may be made at RAAF Base Darwin to enhance current capability. All of proposed capital improvement sites on RAAF Base Darwin are located in the vicinity of the airfield. Please see **Figure 2-1** for location details (PACAF, 2013).

- Construct an aircraft maintenance support facility (6,700 square feet [ft^2], or 622 square meters [m^2]);
- Construct a warehouse to store the Basic Expeditionary Airfield Resource (BEAR) kits (latrines, showers, and billeting shelters) (13,973 ft^2, or 1,298 m^2);
- Extend the ramp at the bomber replenishment area (BRA);
- Construct an aboveground fuel storage tank near Tank Farm #7; and
- Designate a billeting area for approximately 280 airmen; billeting requires access to 8 acres (3.2 hectares) of land with proximity to water, power, and sewer.

2.1.2 RAAF Base Tindal

In order to accommodate USAF aircraft operations, the following proposed capital improvements will need to be made at RAAF Base Tindal. Most of the proposed capital improvement sites are located in the vicinity of the airfield; however, the proposed billeting is located on an unused golf course. Please see **Figure 2-2** for location details (PACAF, 2013).

- Extend and widen the runway to facilitate bomber aircraft usage;
- Build two runway ramps for the bombers, one for armed bombers and one for unarmed bombers;
- Build a fuel storage tank;
- Construct a hangar (26,715 ft^2 [2,482 m^2]) for the Global Hawk UAVs;
- Construct a support facility for fuel storage and cooling (900 ft^2 [84 m^2]);
- Construct two warehouses (6,700 ft^2 [622 m^2] and 13,973 ft^2 [1,298 m^2]);
- Build an earthen-covered munitions igloo; and
- Designate a billeting area for approximately 340 airmen; billeting requires access to 8 acres (3.2 hectares) of land with proximity to water, power, and sewer.



Legend

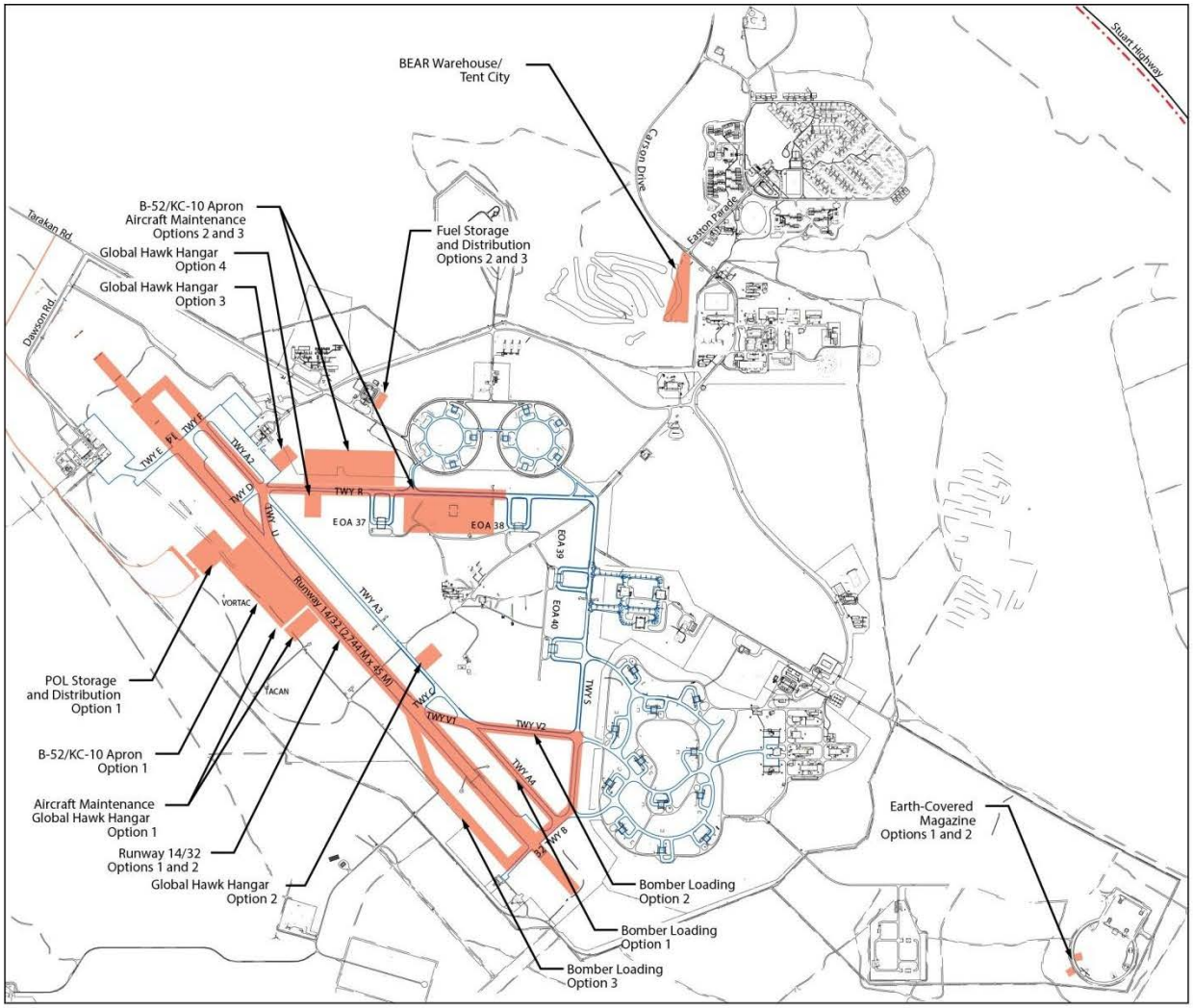
RAAF Base Darwin Boundary

Project Boundary

Scale: 1:20,000

Figure 2-1

RAAF Base Darwin Capital Improvements
PACAF Australia ER



Legend

RAAF Base Tindal Boundary

Airfield Pavement

Project Site Option

0 200 400 800

Scale In Meters

Figure 2-2

RAAF Base Tindal Capital Improvements
PACAF Australia ER

2.2 General Operating Plan

The USAF is preparing to conduct two 15-day exercises annually in the Northern Territory of Australia. These operations will be performed jointly with the RAAF and other allied nations, and will be in addition to existing annual exercise operations such as Talisman Sabre and Pitch Black. These exercises will not occur concurrently with Talisman Sabre or Pitch Black, but could be conducted as an extension of those maneuvers. The proposed exercises will occur during the regional dry season (March–November).

Airmen and aircraft will be stationed at RAAF Bases Darwin and Tindal during the exercises, while training events will occur primarily on Bradshaw Field and Delamere Training Ranges. Roles to be practiced during the training events include:

- Low-level flying;
- Air-to-air combat;
- Air-to-ground attack (bombing, missiles and gunnery);
- Airborne early warning and control;
- Air-to-air refueling; and
- Tactical air transport.

The RAAF has employed Bradshaw Field and Delamere Training Ranges for a number of years, and the environmental impacts associated with their use were analyzed in accordance with the *Australian Environment Protection (Impact of Proposals) Act of 1974*. Because the proposed training activities listed above fall within the scope of events analyzed in Australian environmental impact statements (EISs) for these ranges (RAAF, 1997; RAAF, 1983), impacts resulting from the use of these training ranges are not considered further in this ER.

Below is an explanation of the typical exercise operations to be performed at RAAF Bases Darwin and Tindal.

2.2.1 RAAF Base Darwin

Approximately 280 U.S. airmen will deploy to RAAF Base Darwin to take part in the proposed exercises. Ideally, these airmen will stay in local hotels; however, if space is not available, a tent city or trailer (demountable) billeting area will be established. BEAR kits containing the necessary billeting assets will be permanently stored in a warehouse on the installation.

The aircraft to be used during the training exercises at RAAF Base Darwin include fighters, bombers, and tankers. Characteristically, F-15, B-1, and KC-10 aircraft will be used, although other aircraft, including F-16s, may participate in the exercises as well. **Table 2-1** below details the notional exercise participation at RAAF Base Darwin.

Table 2-1
Notional Exercise Participation RAAF Base Darwin
PACAF Australia ER

Aircraft Type	Number of Aircraft	Missions per Day	Personnel
Bombers	2	2	75
Tankers	2	2	60
Fighters	24	12	145
TOTAL	**28**	**16**	**280**

Operation of these aircraft requires approximately 90,000 gallons (339,000 liters) of fuel per day. Fuel supply will follow existing RAAF supply chains. USAF aircraft will be maintained by USAF personnel and will require the use and generation of hazardous materials, such as lubricants and detergents.

2.2.2 RAAF Base Tindal

Operations during the proposed exercises will be larger at RAAF Base Tindal than at RAAF Base Darwin. Approximately 350 US airmen will deploy to RAAF Base Tindal to participate in the proposed exercises. Billeting will be similar to the arrangements at RAAF Base Darwin. Hotels are preferred but tent cities or trailers will be used if needed. BEAR kits containing the necessary billeting assets will be permanently stored in a warehouse on the installation.

The aircraft to be used during the training exercises at RAAF Base Tindal include fighters, bombers, tankers, and UAVs. Typically, F-15, B-52, KC-10, and RQ-4 aircraft will be used, although other aircraft, including F-16s, may also participate in the exercises. **Table 2-2** below details the notional exercise participation at RAAF Base Tindal.

Table 2-2
Notional Exercise Participation RAAF Base Tindal
PACAF Australia ER

Aircraft Type	Number of Aircraft	Missions per Day	Personnel
Bombers	2	2	75
Tankers	2	2	60
Fighters	24	12	145
UAVs	3	2	60
TOTAL	**31**	**18**	**340**

Operation of these aircraft requires approximately 90,000 gallons (339,000 liters) of fuel per day. Fuel supply will follow existing RAAF supply chains. USAF aircraft will be maintained by USAF personnel and will require the use and generation of hazardous materials, such as lubricants and detergents.

SECTION 3.0

RAAF Base Darwin Important Environmental Issues

This section presents information on the potential environmental issues that may result from USAF operations at RAAF Base Darwin. These issues were identified during a site visit to the installation by PACAF engineers, Air Force Civil Engineer Center (AFCEC) National Environmental Policy Act (NEPA) managers, and USAF environmental contractors on 6-9 November 2012. The information provided below is based on personal conversations with RAAF Defence Support Group (DSG) environmental and estate managers, as well as documents provided during the meetings.

3.1 Utilities

3.1.1 Energy

Energy on RAAF Base Darwin is purchased from the local electric company, and the USAF will have no responsibility in managing this contract. According to Gary Want, Estate Manager, RAAF Base Darwin, the base is operating on the edge of its available electrical capacity. USAF planners should plan on providing backup power for essential operations. The base has natural gas onsite that could be used for electricity generation, or diesel/JP8 fuel.

Impact Minimization: USAF planners will consider backup electrical generation during training exercises to reduce impacts to the current system.

Electricity availability is not expected to be a major obstacle during construction or during conduct of the joint training exercises.

3.1.2 Drinking Water

Drinking water on RAAF Base Darwin is provided by the City of Darwin. Water interruptions are rare and should not be a problem. The drinking water systems on base are operated by the installation's base engineering operations contractor. The USAF will have no responsibility in operating this drinking water system.

According to Robyn Maurer, Senior Environment Manager, RAAF DSG, this drinking water system has supported exercises totaling more than 2,000 temporary personnel. Therefore, with the PACAF planning factor of 280 USAF personnel for two 15-day joint training exercises, drinking water should not be an issue.

Impact Minimization: Not applicable.

Drinking water is not expected to be a problem for the joint training exercises.

3.1.3 Wastewater

Wastewater on RAAF Base Darwin is treated at the City of Darwin wastewater treatment plant (WWTP). The USAF will have no involvement or responsibility in operating that facility.

The City of Darwin has a population in excess of 200,000, making it the largest and most populated city in the Northern Territory. USAF personnel may be housed in base lodging, a tent city, or in hotels in the City of Darwin. If the tent city plan is implemented, PACAF will attempt to connect the latrine and shower facilities to the installation's wastewater collection system. According to Robyn Maurer, RAAF DSG, the 280 USAF personnel projected for the two 15-day joint training exercises will have a minimal effect on the City of Darwin's WWTP.

Impact Minimization: Not applicable.

Wastewater treatment is not expected to be a problem during construction or during the joint training exercises.

3.1.4 Solid Waste

Solid waste on RAAF Base Darwin is collected by an off-base contractor and transported to a solid waste disposal facility in the City of Darwin. The solid waste disposal contract is managed by the installation's base engineering operations contractor, and the USAF will have no responsibility in managing this contract.

According to Robyn Maurer, RAAF DSG, the disposal of additional solid waste from previous training exercises has not been a problem. Recycling is important to RAAF Base Darwin and the local community, and will be emphasized to units participating in these joint training exercises. Types of source separation (such as food/wet waste, plastic, metal, and paper) will be discussed as part of exercise planning because recycling rules may change over time. Sufficient containers for the waste separation will be addressed as part of the exercise planning. Hazardous waste disposal is discussed in Section 3.3, *Hazardous Material and Hazardous Waste*, of this document.

Impact Minimization: When planning for exercises, coordination with the Estate Manager for additional trucks or frequency of solid waste removal may be necessary. Recycling solid waste will be a priority.

Solid waste disposal is not expected to be a problem during construction or during conduct of the joint training exercises.

3.2 Water Quality

There is a surface water monitoring program at RAAF Base Darwin and RAAF DSG personnel stated there were no current surface water quality concerns. The only water quality report received during the sites visits was written in 2002. The report indicated there were no significant surface water concerns and conditions meet the *Australian Water Quality Guidelines for Fresh and Marine Waters,* developed by the Australian and New Zealand Environmental and Conservation Council in 2000 (URS, 2002).

The main surface water drainage system on RAAF Base Darwin is Rapid Creek, which drains to the north (**Figure 3-1**). Rapid Creek is the most important catchment on RAAF Base Darwin because it is the facility's only freshwater creek system and accounts for more than half of the total area of the installation. There is also a 37-acre (15-hectare) wetland, Marrara Swamp, which is located at the head of Rapid Creek (RAAF, 2000).

Rapid Creek is a major concern for the local and Aboriginal communities, and a number of advisory committees actively monitor the catchment. Stormwater from the airfield drains toward Rapid Creek and its associated wetland. The proposed USAF activities could impact the water quality of Rapid Creek by increasing the risk of fuel spills, the addition of impervious area, and runoff from construction.

Impact Minimization: Stormwater runoff from construction activities and the increased impervious area will be addressed in the design of all capital improvement projects. Best management practices (BMPs), such as the installation of oil/water separators near refueling areas, will be implemented to prevent fuel spills from reaching Rapid Creek. USAF units will be directed to carefully implement spill prevention practices in handling and/or storing fuel.

Impacts to Rapid Creek will likely be an issue during the RAAF Siting Board, and it is important that BMPs are included in facility designs. Potential BMPs include oil/water separators and a dyke network of containment systems.

3.3 Hazardous Material and Hazardous Waste

3.3.1 Existing Contamination

Numerous landfill sites are located on RAAF Base Darwin. These landfills contain debris from the Japanese bombing of Darwin during World War II (WWII) (including aircraft wreckage, demolition material, and damaged stocks) as well as demolition debris from damaged buildings and other facilities caused by Cyclone Tracey in 1972. The exact location of the landfills sites cannot be easily determined by visible surface markings and survey drawings. Attempts have been made to locate the landfills (**Figure 3-2**), although new sites are continually identified. Material buried at these sites includes asbestos, metals (including lead), ammunition, and unexploded ordnance (UXO) (RAAF, 2000).

Impact Minimization: Should suspected contaminated material be discovered during construction, activities would cease and a RAAF DSG officer will be contacted immediately. The RAAF DSG officer will assess the material and, if necessary, arrange for a properly trained and licensed contractor to clean up the contaminated material (Gilligan, 2012).

Impacts from existing contamination are not expected to be a problem during construction or during conduct of the joint training exercises.

Figure 3-1
Rapid Creek near RAAF Base Darwin
PACAF Australia ER

Figure 3-2
RAAF Base Darwin Contaminated Sites
PACAF Australia ER

3.3.2 Hazardous Materials and Waste

The most significant environmental issue on RAAF Base Darwin is the storage and handling of hazardous materials, particularly fuels (RAAF, 2000). Apart from catastrophic events, such as aircraft accidents, the primary potential for soil, surface water, and groundwater contamination during normal base operations results from the storage and handling of aviation fuel.

Hazardous substances stored at RAAF Base Darwin include bulk liquid oxygen, bulk liquid nitrogen, liquid petroleum gas in tanks and cylinders, oxygen, acetylene, compressed air, argon, solvents, paints, sodium hypochlorite, and chemical maintenance substances (RAAF, 2000). Generally, hazardous waste is containerized and transported by contractors to Adelaide, located on the south-central coast of Australia.

The only unique hazardous materials the USAF will transport when deploying to Australia is hydrazine. Otherwise, the hazardous materials utilized will be standard petroleum, oils, and lubricants currently used on Australian aircraft. Hydrazine was of specific concern to the RAAF DSG. Hydrazine is a highly toxic and flammable propellant used in F-16 aircraft. Hydrazine is not currently used by the RAAF, although it has been used by other nations operating on RAAF Base Darwin that fly F-16 aircraft.

Impact Minimization: Hazardous material and hazardous waste management plans will be developed specific to USAF operations at RAAF Base Darwin. All hazardous material used by the USAF will be handled in accordance with U.S. Department of Defense (DoD) operating procedures and regulations, including Air Force Joint Manual (AFJMAN) 23-209, *Storage and Handling of Hazardous Materials*. Specifically, all hazardous material dispensing areas will be properly maintained, drums/containers must not be leaking, drip pans/absorbent materials will be placed under containers as necessary to collect drips or spills, container contents will be clearly marked, and all personnel handling the hazardous material will be properly trained. Additionally, a hazardous waste accumulation point will be operated to provide appropriate segregation for different waste streams. When available, USAF will use established RAAF hazardous waste accumulation points. Hydrazine will be handled in accordance with established neutralization procedures (Technical Order 1F-16C-2-49GS-00-1).

The use and management of hazardous materials were the most significant environmental issues raised by RAAF environmental personnel during the site visit. The largest concern was the potential for fuel spills to impact Rapid Creek. It is important that the USAF adhere to its established protocols, and BMPs, such as oil/water separators, are put in place to reduce the likelihood of spills reaching Rapid Creek.

3.4 Transportation

Ground transportation to RAAF Base Darwin is by way of Stuart Highway, which passes outside the facility's Main Gate. Most material is shipped into the Port of Darwin and trucked by road train to the installation.

According to Robyn Maurer, RAAF DSG, the anticipated additional bus and truck traffic needed to support joint exercises will have minimal impact on traffic along Stuart Highway. Large training exercises conducted in the past have caused major impacts to base traffic and

parking, but have not adversely impacted traffic on the highway. Similarly, previous construction projects on RAAF Base Darwin have not caused apparent impacts to Stuart Highway traffic.

Impact Minimization: USAF personnel will have limited access personal vehicles while onsite and will rely on RAAF-provided buses or rental buses/trucks when possible, thereby reducing the traffic footprint during the proposed exercises.

Traffic is not expected to be a problem during construction or during conduct of the joint training exercises.

3.5 Air Quality and Greenhouse Gases

Air quality in Australia is regulated by the Ambient Air Quality -- National Environment Protection Measure (AAQ NEPM). This measure requires each jurisdiction to submit an annual air monitoring compliance report. A screening analysis is performed to determine which pollutants should be monitored based on the level of concern for an impact. Based on the most recent screening analysis, completed in 2001, the primary pollutants of concern in the Darwin area are from particulates (particulate matter less than 10 micrometers [PM_{10}] and 2.5 micrometers [$PM_{2.5}$] in aerodynamic diameter). The screening analysis indicated that nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), and lead aerosols were not a cause for concern relative to the AAQ NEPM standards (Northern Territory, 2010).

In the United States, air quality is regulated at the federal level by the *Clean Air Act* (CAA). One component of the CAA is that areas are classified either as attainment if the measured ambient concentrations of pollutants are below federal standards, non-attainment if measured concentrations exceed the standards, or unclassified if not enough monitored data exist for that area. In the United States, fewer controls or emission limitations are placed on projects located in an attainment or unclassified area. Additionally, significance thresholds, the quantitative amount of emissions a project can emit before causing a significant impact to air quality, are also defined based on a project's area classification. In the United States, if a project is below the threshold of significance, then it is not expected to cause an impact to air quality.

Australia does not have quantifiable significance thresholds for projects to determine the potential impact to air quality. Therefore, for the purposes of this evaluation, the U.S. standards are used as a quantitative threshold based on the Australian ambient air conditions. For example, based on the 2010 ambient air monitoring report, the Darwin area met the AAQ NEPM standards. Therefore, the existing conditions of the ambient air in the Northern Territory would be considered in attainment or unclassified by U.S. standards, and the corresponding U.S. quantitative threshold of significance will be used to determine the potential impact to air quality for the project.

Air quality was not a resource of concern for RAAF Base Darwin DSG personnel. The RAAF is not considered a large emitter of pollutants under the *Waste Management and Pollution Control Act* (Department of Natural Resources, Environment, the Arts and Sport, 2011), and is not required to obtain an environmental license under this act. This further indicates that air quality is not an issue for concern.

Greenhouse gases (GHGs) are regulated at the national level by the National Greenhouse and Energy Reporting (NGER). Currently, the RAAF is not a part of the NGER reporting program so it is unlikely that the project will cause a significant GHG impact.

Sources and Thresholds

The construction of the capital improvements and the joint exercises will generate air emissions. Construction sources will include earth moving equipment, building equipment, delivery trucks, and personnel transport. These sources will generate U.S.-recognized criteria pollutants (particulates PM_{10} and $PM_{2.5}$, CO, NO_X, SO_2, and GHG pollutants (carbon dioxide [CO_2]). The scale and duration of construction will be a source of short-term, temporary emissions. Construction emissions will also result in far fewer emissions than operation of the training activities, which are quantified below. Therefore, only the emissions associated with the training operations were quantified to determine the relative impact to air quality in the region.

Joint exercise emission sources will include aircraft, fueling/ground equipment, commercial buses (personnel transportation), fuel transfer operations, on-the-ground stationary combustion equipment, and fuel storage tanks. It is assumed that the primary source of emissions will be from the combustion of fuel in aircraft, and that the other sources will be relatively minor by comparison. The total fuel combusted per aircraft engine was used in conjunction with the Air Force Center for Engineering and the Environment (AFCEE) *Air Emissions Factor Guide to Air Force Mobile Sources* (AFCEE Mobile Guide) to estimate the operational emissions (AFCEE, 2009). Aircraft emissions will include the following components: approach, takeoff, and climb out (idle time was not included in accordance with the ACFEE Mobile Guide because it is not a part of standard training activities). These estimated emissions were compared to the relative thresholds identified below to determine if air quality in the region would be impacted.

Because the Northern Territory is the equivalent of a U.S. attainment area, the proposed thresholds of significance for criteria pollutants would be the General Conformity thresholds for an attainment or unclassified area, which is 100 tons per year. In Australia, the national reporting framework for GHGs is the *National Greenhouse and Energy Reporting (NGER) Act*. The facility-level reporting in Australia is 25,000 metric tons (MT) per year, which is similar to the U.S. Council on Environmental Quality (CEQ) guidance; however, this is simply a reporting threshold and does not necessarily indicate a significant impact. If the GHG emissions are likely to be greater than 25,000 MT of CO_2 equivalents (CO_2e), then the emissions were quantified. The environmental issues associated with ambient air quality and GHG emissions are discussed in the following sections.

3.5.1 Ambient Air Quality

The Darwin/Palmerston region (population of 124,760) and Alice Springs (27,895 residents) area are the only areas in the Northern Territory that exceed the population threshold for ambient air quality monitoring (Northern Territory, 2010).

The primary air pollutant of concern in the Northern Territory was particulates from landscape fires in the Darwin region (Northern Territory, 2011). NO_X, SO_2, CO, O_3, and lead aerosols were not a cause for concern in the Darwin/Palmerston region relative to the

Ambient Air Quality National Environment Protection Measure (NEPM) standards (Northern Territory, 2010).

Based on the 2010 ambient air monitoring report, the Darwin area met the AAQ NEPM standards. Therefore, the existing conditions of the ambient air in the Darwin area would be classified as the equivalent of attainment in the United States.

Based on 2010 – 2011 inventory data, the RAAF is not currently required to obtain air permits or register as a part of the National Pollution Inventory (NPI) (NPI, 2012b). This is consistent with requirements in the United States, where military aircraft engines are exempt from the federal aircraft engine NO_X emissions standards in 40 CFR 87 and are not subject to permitting requirements or other federal stationary or mobile source emissions standards or regulations.

As shown in **Table 3-1**, the estimated emissions for the aircraft training operations at RAAF Base Darwin are all less than 100 tons per year for U.S. criteria pollutants. Details of the air emission calculations are included in **Appendix A**.

Table 3-1
Estimated Emissions for Aircraft Training Operations, RAAF Base Darwin
PACAF Australia ER

Aircraft Type	Emissions (ton/year)				
	NO_x	CO	VOC	PM_{10}	$PM_{2.5}$
Bomber (B-52)	23	13	4	1	1
Tanker (KC-135)	29	13	0.1	0.4	0.3
Fighter (F-22)	25	16	1	5	4
Darwin Aircraft Total Annual Criteria Emissions:	**77**	**42**	**5**	**7**	**6**

Notes: Numbers in columns may not add up exactly due to rounding.
VOC = volatile organic compound

Because the primary air quality issue in the Darwin area is from dust, and the particulate emissions associated with the training activities are much lower than 100 tons per year, it is unlikely the additional training will create an environmental impact to air quality in the region. However, prevention of dust emissions during construction is advised.

Impact Minimization: The use of standard BMPs, such as watering bare areas, to control dust emissions will be implemented during construction.

Ambient air quality should not be an issue during construction or during conduct of the joint training exercises.

3.5.2 Greenhouse Gas

The Australian NGER Scheme was introduced in 2007 to provide data and accounting in relation to GHG emissions and energy consumption and production. The two components of the NGER Scheme directly relative to the RAAF are the carbon pricing mechanism and the GHG reporting thresholds (NGER, 2012a). Because the RAAF is not a registered GHG reporter, it is not considered one of "Australia's biggest polluters" of GHGs and, therefore, will not have to pay a price for its carbon emissions (NGER, 2012c). However, it is likely that the RAAF will still be affected by the NGER Scheme because it is expected that costs for petroleum products will increase to offset the costs the suppliers are required to pay for "their carbon pollution."

To provide an estimate of the impact of GHG emissions during USAF operations, the GHG emissions associated with the combustion of fuel from aircraft during training exercises were quantified. These emissions at RAAF Base Darwin were approximately 25,300 MT CO_2e. Although these emissions are just slightly above the quantification threshold of 25,000 MT CO_2e, they are much lower than permit thresholds for stationary sources in the United States. Furthermore, because these sources are not stationary sources, they would likely still not be considered a major source of GHG pollutants because most of the regulations are aimed at reducing stationary source emissions. In addition, the installation is taking steps to decrease its carbon footprint at RAAF Base Darwin, which will reduce the facility's impact to climate change through the generation of fewer GHG emissions.

Impact Minimization: Not applicable.

GHG emissions should not be an issue during construction or during conduct of the joint training exercises.

3.6 Biological Resources

3.6.1 Sensitive Species

USAF operations will take reasonable steps to protect known U.S. endangered or threatened species and Australian protected species and their habitats. The following discussion covers both U.S. and Australian sensitive species.

Twenty-one Australian animal species are listed as threatened or endangered under the U.S. *Endangered Species Act* (ESA). Of the 21 Australian species, two occur within the vicinity of RAAF Base Darwin: the saltwater crocodile (*Crocodylus porosus*), which is listed as threatened, and the false water mouse (*Xeromys myoides*), which is listed as endangered.

The saltwater crocodile is found in Australian coastal waters, estuaries, freshwater lakes, inland swamps, and marshes. While the saltwater crocodile is listed on the ESA, it is listed as a species of least concern in the Northern Territory under the Australian EPBC and the *Territory Parks and Wildlife Conservation Act of 2009* (Australia, 2013). The U.S. ESA designation was in response to over-exploitation for the skin trade, and makes it illegal to trade non-captive-bred specimens in the United States (*Federal Register*, 1996). While saltwater crocodiles may occur on RAAF Base Darwin, they prefer marine environments and are unlikely to be found in the vicinity of the Proposed Action. Furthermore, saltwater crocodiles are a very large (up to 5 meters [15 feet] in length) and aggressive species.

Airmen and contractors will be made aware of the protected status of the species in the United States and warned, for their own protection, to avoid the species and its habitat.

Forty-eight species in the vicinity of RAAF Base Darwin are listed as threatened or vulnerable under the Australian *Environment Protection and Biodiversity Conservation Act (EPBC) of 1999.* This list includes the U.S. ESA-listed false water rat, which is EPBC-listed as vulnerable. Extensive threatened species surveys were conducted on RAAF Base Darwin in 2012. The survey focused on EPBC-listed species, including the false water rat. No listed species were identified during the survey; however, suitable habitat for the false water rat was present in the Marrara Swamp area (EcoLogical, 2012). Because the proposed capital improvement sites and exercise operations areas are all located in highly disturbed and developed areas and away from the Marrara Swamp, the likelihood of USAF actions at RAAF Base Darwin impacting a listed species is remote.

Despite the lack of EPBC-listed species found on the installation, all Australian native vertebrate animals living in the Northern Territory are protected under the *Northern Territory of Australia Territory Parks and Wildlife Conservation Act of 2011*. Therefore, it is important that USAF operations do not harm native Australian vertebrates.

Impact Minimization: Airmen and construction contractors will be informed of the protected status of all Australian vertebrates and advised to avoid harming any animals.

Construction and operation activities are not expected to impact sensitive species.

3.6.2 Biosecurity

The natural landscapes of the Northern Territory are largely still intact, due to the relative isolation and remoteness (Northern Territory, 2011). Consequently, exotic weeds, pests, and diseases can have devastating effects on soil, native vegetation, wildlife, crops, and livestock. Insects are the pest that poses the greatest potential risk to the Northern Territory.

The Australian Government Department of Agriculture, Fisheries, and Forestry (DAFF) manages quarantine controls to minimize the risk of exotic pests and diseases entering the country. DAFF (formerly the Australian Quarantine and Inspection Service [AQIS]) develops procedures and provides services to ensure adequate quarantine and inspection occurs for all vessels, aircraft, vehicles, machinery, goods, cargo, and personal effects entering Australia from foreign nations. The RAAF, along with a number of other regional organizations, has developed plans to control the spread of exotic species (RAAF, 1999; Northern Territory, 2011). RAAF Base Darwin has approved quarantine wash facilities for cleaning vehicles and equipment returning from overseas, with captured solids regarded as quarantine waste (RAAF, 2001).

The United States normally asserts the privilege of sovereign immunity for all U.S. State aircraft vessels, and thus does not consent to the boarding and inspection of such aircraft and vessels by foreign government authorities. However, satisfaction of Australia's biosecurity requirements is essential to control the risks posed by weeds, pests, and diseases. Further, Article 13 of the 1963 Agreement between the Government of the Commonwealth of Australia and the Government of the United States of America concerning the Status of United States Forces in Australia states that the U.S. Government shall conform to Australian laws and regulations, including quarantine laws. Consequently,

all USAF aircraft, equipment, and food supplies (including meals ready to eat [MREs]) will need to undergo a quarantine process prior to operations in Australia.

Impact Minimization: The USAF will conform to the policy and procedures agreed to by DAFF, U.S. DoD, and the U.S. Department of Agriculture (USDA) for the Talisman Sabre exercise in 2013. This policy regarding biosecurity was developed by the U.S. Embassy in Australia and USPACOM for sovereign immune assets (U.S. vessels and aircraft) entering Australia for the Talisman Sabre combined military exercises on mainland Australia. The U.S. does not normally assert sovereign immunity for U.S. machinery, vehicles, goods, cargo, or personal effects that are off-loaded from a U.S. aircraft. Unless sovereign immunity is specifically asserted, such items will undergo normal DAFF-approved biosecurity inspections upon arrival into Australia or by special arrangement prior to departure for Australia.

Biosecurity is a very important issue in Australia because the country is relatively free of many of the animal and plant diseases affecting other nations. If the USAF conforms to the 2013 Talisman Sabre quarantine agreements, biosecurity should not be a problem during construction or during conduct of the joint training exercises.

3.7 Wildfire

Wildfires generally occur at RAAF Base Darwin every dry season. The most susceptible area is Marrara Swamp, although isolated pockets and boundaries may also be burned out. Lightning strikes or arson by local children are generally thought to be the main cause of the wildfires. A network of firebreaks exists on RAAF Base Darwin, particularly in the explosive ordnance storage area and around the boundary fence line (RAAF, 2000). The RAAF Base Darwin DSG has an active fire management program, which includes prescribed burning during the wet season (Wildman Land Management, 2005) and the DIA manages the fire response for the RAAF Base Darwin airfield.

Impact Minimization: Not Applicable**.**

Wildfires are not expected to be a problem during construction or during conduct of the joint training exercises.

3.8 Heritage

3.8.1 Aboriginal Heritage

The northern portion of RAAF Base Darwin is located on the Rapid Creek catchment, which incorporates part of the traditional land of the Larrakia peoples. Their association with the area continues today. Nonetheless, the Northern Territory Aboriginal Areas Protection Authority has no registrations of sacred or significant sites located on RAAF Base Darwin, although a few potential sites have been identified in the Marrara Swamp area (RAAF, 2001). These sites are located away from any proposed USAF-sponsored capital improvements sites and expected USAF activity areas.

Impact Minimization: Given the extent of clearing and ground disturbance in the airfield area, it is unlikely that new Aboriginal heritage sites would be found during construction or the exercise operations. However, if any artifacts are discovered during construction or

exercises, all activities at the site will cease and RAAF DSG contacted. The RAAF DSG will manage the site in accordance with Australian regulatory requirements.

Impacts to Aboriginal heritage sites are not expected to be a problem during construction or during conduct of the joint training exercises.

3.8.2 European Heritage

RAAF Base Darwin contains a largely intact set of buildings illustrating the form and layout of an Australian Air Force Base built in the lead-up to WWII. The southwest corner of RAAF Base Darwin has been identified as a heritage precinct due to the presence of buildings dating from the original development of the base. Remnants of structures such as defensive positions and the railway used to service the base in WWII remain scattered throughout the installation. While these structures are not listed with the current Heritage Precinct area on the Commonwealth Heritage List, they add heritage value to the facility. The heritage district and individual historic features are located away from the airfield and proposed USAF capital improvement sites (Environmental Resource Management, 2005).

Impact Minimization: New structures will be designed in accordance with the standards detailed in the RAAF Base Darwin Master Plan Report (Woods Bagot, 2009), thereby ensuring that any new facilities integrate with the historic character of the installation.

Impacts to European heritage sites are not expected to be an issue during construction or during conduct of the joint training exercises.

3.9 Health and Safety

3.9.1 Wildlife Strikes

Wildlife can pose a significant hazard to the safe conduct of aircraft operations. The vast majority of bird or wildlife strikes occur either on or within the immediate proximity of a runway, and in many strike events, damage is sustained to the aircraft. In serious incidents, damage from a strike could result in the aircraft being unable to maintain safe operations. The airfield at RAAF Base Darwin is a particular challenge due to the tropical environment supporting numerous bird and animal species, including bats and migratory birds (DIA, 2011).

DIA is responsible for implementing the bird and animal hazard management system for the runways it shares with RAAF Base Darwin. DIA has developed a program that consists of a combination of facets of bird and other animal management to provide a safe operating environment for all aircraft utilizing the airfield. The following are a few methods used to deter wildlife away from the airfield:

- Manage grass height;
- Control vegetation;
- Perform landscaping to avoid roosting opportunities;
- Avoid the creation of perches;
- Remove dead animals, termite mounds, and nests;
- Coordinate land use off base; and
- Report wildlife activity and incidents (DIA, 2011).

Impact Minimization: DIA has an ongoing wildlife management program and, therefore, wildlife strikes should not be a major issue during conduct of the joint training exercises. However, The USAF will report any wildlife strikes to RAAF DSG, which will communicate the information to DIA. This will allow the DIA to properly manage bird strikes on the RAAF Base Darwin airfield.

Wildlife strikes should not be an issue during USAF operations.

3.9.2 Insect-Borne Disease

The area around RAAF Base Darwin is classified as a potential entry point for mosquito-borne diseases by the World Health Organization (WHO). Mosquito-borne diseases of concern around Darwin chiefly originate from Asia and include Ross River virus, Barmah Forest virus and Murray Valley encephalitis. Marrara Swamp is considered a major mosquito-breeding area and is located less than 1,300 feet (400 meters) from the airstrip. RAAF Base Darwin has an ongoing mosquito management strategy (RAAF, 2001).

The period of greatest mosquito activity in the Northern Territory occurs during the wet season in December and January (Northern Territory Department of Health, 2012), and not during the expected period of the joint training exercises. Nonetheless, mosquitoes are present outside this period and measures will be taken to reduce the likelihood of mosquito bites.

Impact Minimization: USAF personnel will implement the following personal protection measures while in the Northern Territory to reduce the risk of contracting and spreading insect-borne illnesses:

- Avoid areas known to have high mosquito activity (i.e., Marrara Swamp);
- Remain inside insect-screened buildings when possible;
- Use mosquito nets at temporary camps or unscreened buildings;
- Use repellents containing DEET;
- Avoid the use of white light at campsites (Northern Territory Department of Health, 2011); and
- Treat uniforms with permethrin.

Insect-borne diseases should not be a problem during the joint training exercises; however, precautions should be taken to avoid mosquito bites.

3.9.3 Unexploded Ordnance (UXO)

The inadvertent discovery of UXO on RAAF Base Darwin during construction is possible. During WWII, the Japanese bombed Darwin on 62 occasions (Environmental Resource Management, 2005). According to Gary Want, Estate Manager, RAAF Base Darwin, UXO has mostly been found in the Darwin harbor area. However, RAAF Base Darwin was a frequent Japanese target and UXO has been discovered on the installation. Therefore, all construction and USAF personnel will be made aware of the potential for UXO discovery. If a fragment of UXO or suspected UXO is discovered, personnel will be directed to stop work, leave the ordnance untouched, evacuate the area, and contact RAAF personnel.

Impact Minimization: UXO training as prescribed by RAAF Base Darwin and PACAF will be provided to appropriate construction and USAF personnel to reduce risks associated with potential UXO contact.

UXO is not expected to be a major issue during construction or during conduct of the joint training exercises.

3.10 Noise

The U.S. DoD requires assessment of potential noise impacts and encroachment in accordance with DoDD 3200.15, *Sustainment of Ranges and Operating Areas*. Guidance for noise analysis is provided by the Defense Noise Working Group (DNWG). USAF noise policy is specified in Air Force Instruction (AFI) 32-7063, *Air Installation Compatible Use Zone Program* and Air Force Handbook (AFH) 32-7084, *Air Installation Compatible Use Zones* (*AICUZ) Program Managers Guide*. The RAAF DSG provides guidance for Australian noise analysis. The noise metrics used by U.S. DoD and RAAF DSG are different; however, metrics used by RAAF DSG are recommended as supplemental metrics by DNWG. Therefore, the noise analysis in this ER provides utility for PACAF and RAAF DSG decision makers.

While the proposed PACAF exercises will be relatively small, there are sensitivities of how noise is assessed and presented to Australian decision makers and the public. There is growing concern among the local community regarding military fighter aircraft noise at RAAF Bases Darwin and Tindal, among other Australian locations. BaseWatch, a community action group in Darwin, has become increasingly active over the past 2 to 3 years, according to RAAF DSG Northern Territory environmental managers.

The noise analysis was conducted according to established U.S. DoD guidelines and best practices, and leveraged the DoD NOISEMAP suite of computer-based modeling tools. The suite primarily includes BaseOps, NMAP, the Advanced Acoustic Model (AAM), and NMPlot.

Four categories of aircraft are modeled: Fighters (e.g., F-15 and F-22), Tankers (e.g., KC-10 and KC-135), Bombers (e.g., B-1 and B-52), and Reconnaissance (RQ-4). The loudest aircraft type of each category (on a single-event basis) was modeled, i.e., F-22 for Fighters, KC-10A for Tankers, and B-1 for Bombers. The Citation X (CITX) was chosen as a conservative surrogate for RQ-4 flight operations because there are no acoustic reference data for the RQ-4 in the models. The T-45 was selected as the surrogate for RQ-4 run-up operations because there are no acoustic reference data for the RQ-4 (or for the CITX) in the models.

The United States and Australia rely on cumulative metrics for evaluation of noise exposure. In the United States, the DoD (DoDI 4165.57) requires cumulative noise exposure to be described and presented in terms of Day-Night Average Sound Level (DNL). DNL is a composite noise metric accounting for the sound energy of all noise events in a 24-hour period. Flight and run-up events are measured in terms of their (integrated, normalized to 1 second) Sound Exposure Level (SEL) and (instantaneous) Maximum Sound Level (Lmax), respectively. SEL and Lmax are expressed in A-weighted decibels (dB or dBA). In order to account for increased human sensitivity to noise at night, a 10-dB penalty is applied to nighttime events (10 p.m. to 7 a.m. period).

The RAAF DSG requires cumulative noise exposure to be described in terms of the Australian Noise Exposure Forecast (ANEF). Like DNL, ANEF is a composite noise metric accounting for the sound energy of all noise events in a 24-hour period; however, ANEF is based on Effective Perceived Noise Level (EPNL) for flight events and Tone-Corrected Perceived Noise Level (PNLT) for run-up events. EPNL and PNLT are expressed in decibels of perceived noise (PNdB). The other differences between DNL and ANEF are ANEF's nighttime period is from 7 p.m. to 7 a.m. and its nighttime penalty is 6 dB.

DNWG has provided guidance for supplemental noise metrics including Number of Events (at or) Above a Selected Threshold (NA) and Time (at or) Above a Selected Threshold (TA) (DNWG, 2009). For NA and TA, thresholds of 70, 85, and 100 dBA L_{max} were selected. As companion to the NA and TA maps, the L_{max} was also computed with showing contours of 70, 85, and 100 dBA.

Baseline military and civilian activity at Darwin was previously modeled using the Federal Aviation Administration's (FAA) Integrated Noise Model (INM) Version 6.2a for the ANEF, Lmax, and NA metrics. The prior Darwin INM files were provided by RAAF DSG (DSG, 2010). The baseline data were re-run in INM with appropriate weather conditions to compute average annual day (AAD) DNL. AAD considers total annual operations averaged over 365 days. NMAP was used to compute DNL and ANEF for PACAF exercise aircraft operations. AAM was used to compute NA, TA, and Lmax. NMAP 7.2 is not able to compute NA, TA, or Lmax. Full details of modeling assumptions and methodology are provided in **Appendix B**.

DNL and ANEF were computed for both AAD and average busy day (ABD) operations. Lmax, NA, and TA were only computed for ABD, where ABD represents a typical PACAF exercise day as shown in **Table 3-2**. USAF policy for significant noise impact is determined on a case-by-case basis due to the wide variety of aircraft (e.g., fighters, heavies, props, etc.) and operation types (year-round operations to short-duration exercises) at differing locations (urban to rural). In general, an increase of 2 dB or greater within the AAD DNL 65-dB noise contour is considered significant.

The AAD DNL for the Baseline and the Proposed Action are shown in **Figure 3-3** and **Figure 3-4**, respectively. Comparison of the Proposed Action to the Baseline AAD DNL is shown in **Figure 3-5**. From **Figure 3-5,** it can be seen that the increase in AAD DNL for the Proposed Action is minimal for all areas with some increase west of the runway. No noise sensitive area within the AAD DNL 65-dB noise contour will experience an increase of 2 dB or greater. Therefore, in accordance with USAF policy, there is no significant impact from the Proposed Action. Further, minimal impacts to wildlife are expected as animal populations residing in the regions are accustomed to aircraft noise and the minimal increase should not result in a noticeable increase in disturbance compared to current conditions.

The ABD DNL is shown in **Figure 3-6** to depict elevated noise exposure during the proposed exercise.

Noise levels at select points of interest (POIs), shown in **Figure 3-7**, were also computed. The POIs are located north and southwest of the airfield and consist of four hospitals, eight schools, and seven places of worship. ABD noise levels for all metrics are tabulated for each

POI in **Table 3-2**. ABD represents noise levels experienced during an exercise day. ABD DNL will not exceed 65 dB at any POI. The supplement metrics are more instructive for understanding exposure during an exercise day. At nine POIs, up to 14 events (12 fighter and two bomber departures) will exceed 70 dB for up to 8.5 minutes per day, but much less at most POIs. At eight POIs, up to one event would exceed 85 dB for less than 1 minute per day. No event will exceed 100 dB at any POI. This analysis assumes a conservative (overestimate) worst-case scenario with the loudest fighters (F-22) and bombers (B-1). If different aircraft were used, then the exposure will be less. Additionally, the levels presented reflect outdoor noise levels. Indoor noise levels will be attenuated by approximately 15 or 25 dB for windows open or closed, respectively (USEPA, 1974). The intuitive conclusion is that noise exposure at the POI during the proposed exercise will be noticeable with single events noise levels increasing above ambient noise levels; however, exposure will not be intrusive or significant.

Noise contour maps of Lmax, NA, TA, and ANEF are presented in **Appendix B**.

Impact Minimization: Aircraft will be operated in compliance with aircraft operating and local noise abatement procedures. Current rules restrict fighters from departing after 10 PM.

The proposed PACAF exercises at RAAF Base Darwin will not cause significant noise impacts based on USAF policy.

Table 3-2
POI Noise Exposure for ABD Aircraft Operations at RAAF Base Darwin
PACAF Australia ER

PIO				NA (events)			TA (minutes)		
ID	Description	DNL (dB)	Lmax (dB)	70 dB Lmax	85 dB Lmax	100 dB Lmax	70 dB Lmax	85 dB Lmax	100 dB Lmax
DH-1	Royal Darwin Hospital	<45	80	2	0	0	1.4	0	0
DH-2	Darwin City Medical Centre	<45	79	2	0	0	1.2	0	0
DH-3	Darwin Day Surgery	57	90	13	1	0	6.4	0.5	0
DH-4	Top End Medical Centre	50	81	10	0	0	2.4	0	0
DS-1	Nightcliff Middle School	55	89	9	1	0	5.6	0.4	0
DS-2	Millner Primary School	63	94	14	1	0	7.7	0.7	0
DS-3	Jingili Primary School	57	87	14	1	0	7.2	0.4	0
DS-4	Anula Primary School	56	86	14	1	0	8.5	0.2	0
DS-5	Alawa Primary School	54	85	14	0	0	4.8	0	0
DS-6	Wagaman Primary School	52	83	14	0	0	4.4	0	0
DS-7	Sanderson Middle School	53	84	14	0	0	6.1	0	0
DS-8	Northern Territory Open Education Centre	57	90	10	1	0	6.0	0.5	0
DW-1	Islamic Society of Darwin	50	81	10	0	0	2.4	0	0
DW-2	Christ Cathedral Anglican	<45	77	2	0	0	1.3	0	0
DW-3	Lutheran Church of Australia	61	93	14	1	0	7.1	0.8	0
DW-4	Greek Orthodox Church	<45	80	2	0	0	1.2	0	0
DW-5	Abundant Life Christian Church	46	78	2	0	0	2.1	0	0
DW-6	Darwin Baptist Church	55	87	14	1	0	6.7	0.4	0
DW-7	Assemblies of God	52	84	14	0	0	4.0	0	0

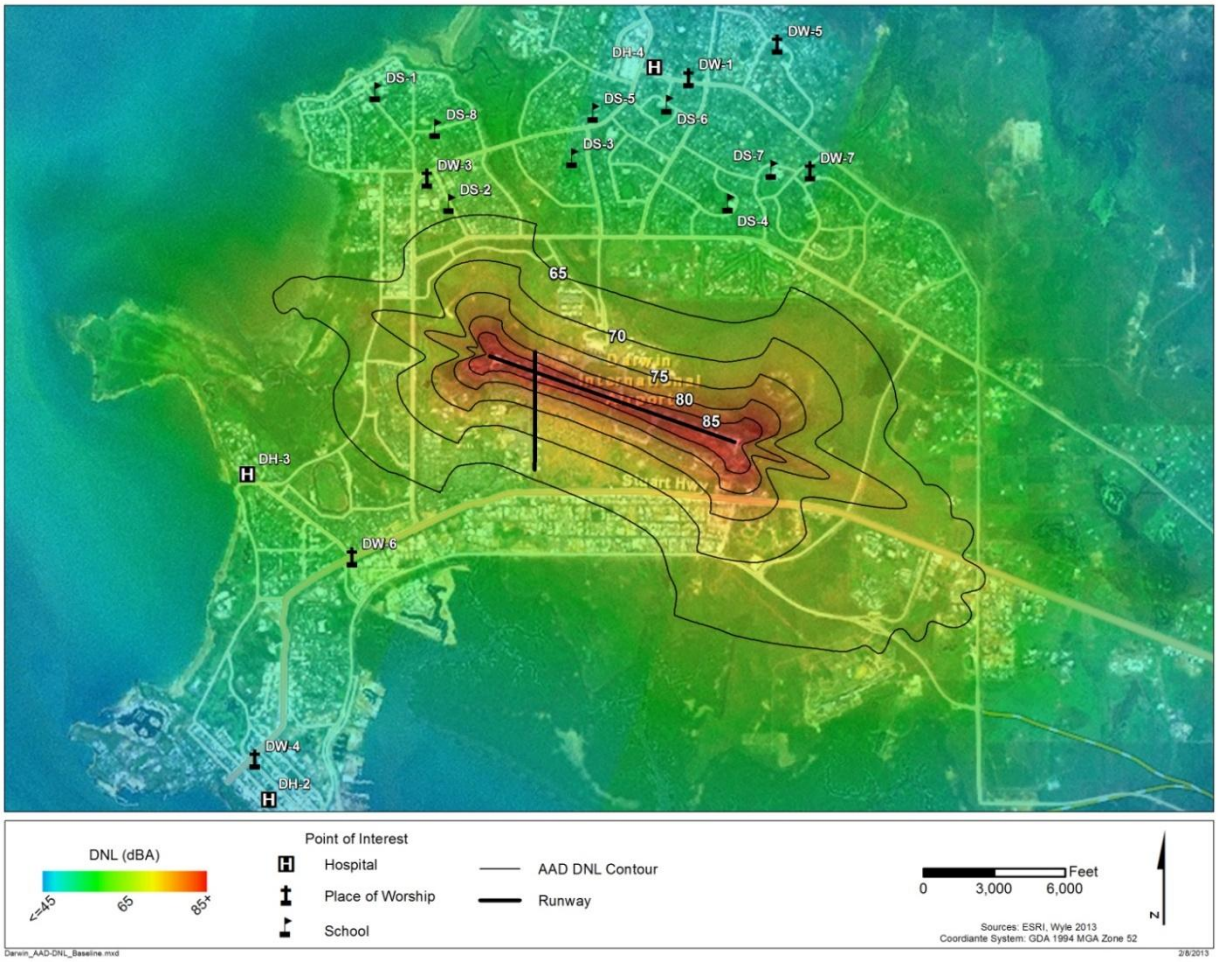


Figure 3-3
DNL Contours and Gradient for Baseline AAD Aircraft Operations at RAAF Base Darwin
PACAF Australia ER

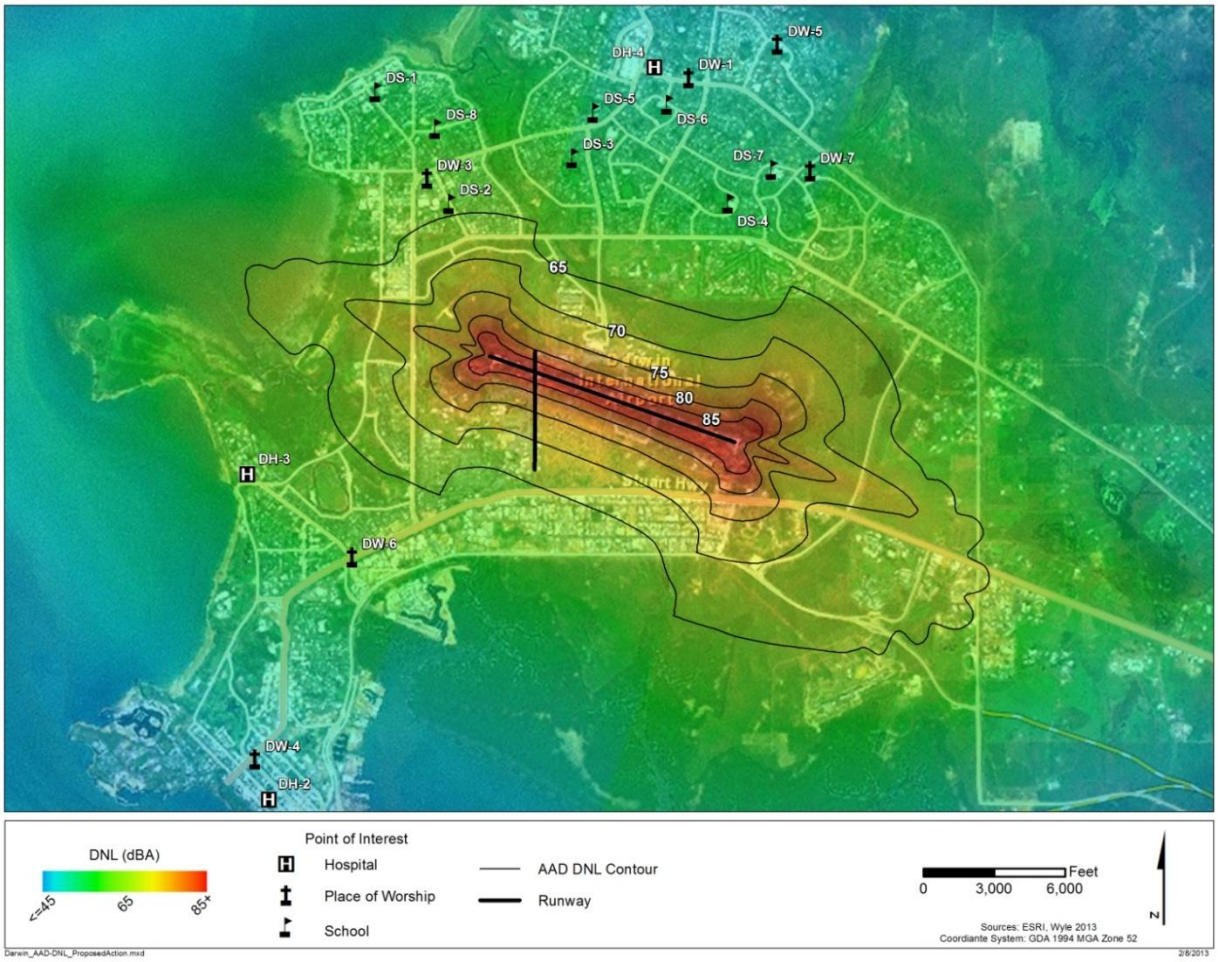


Figure 3-4
DNL Contours and Gradient for Proposed Action AAD Aircraft Operations at RAAF Base Darwin
PACAF Australia ER

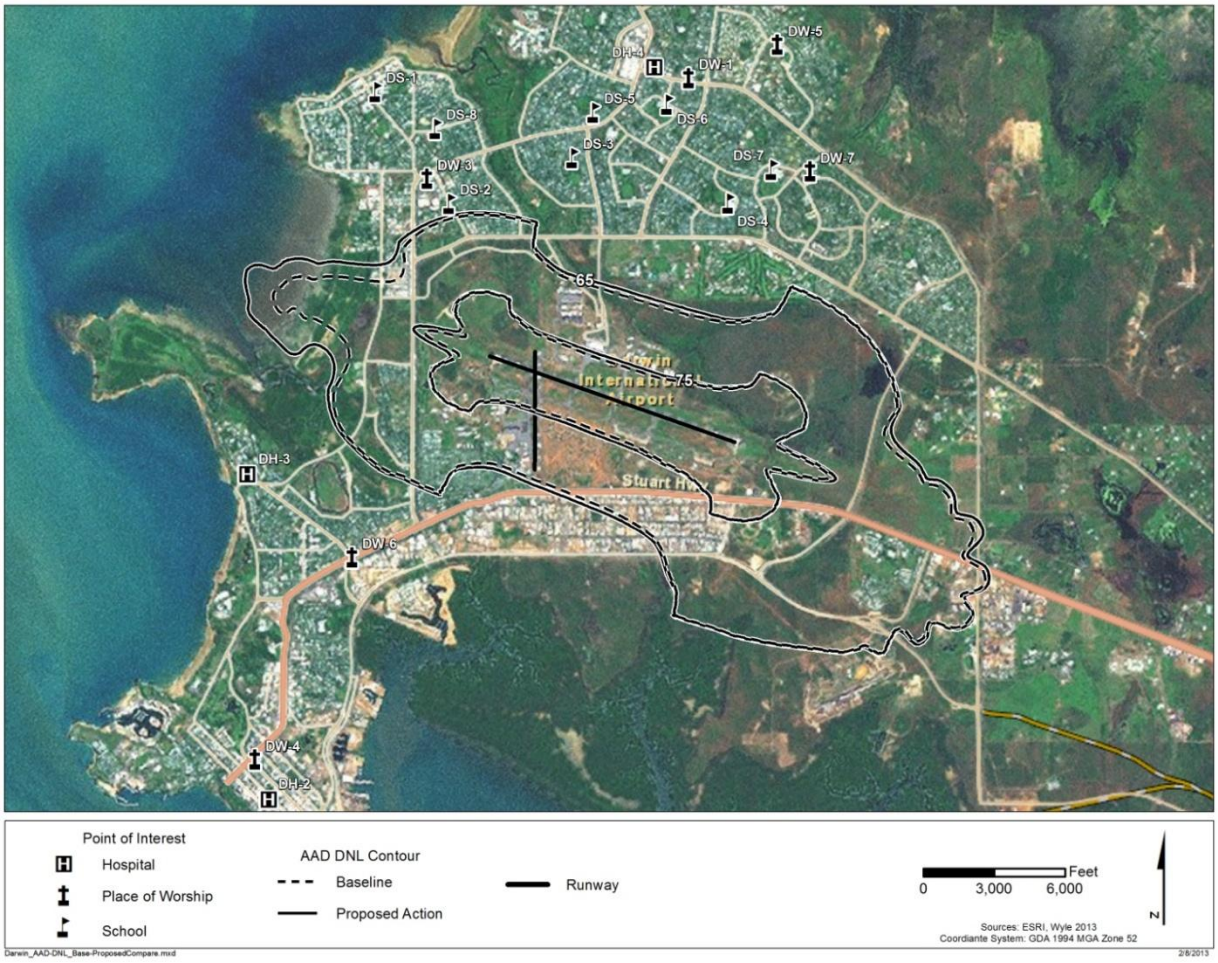


Figure 3-5
Comparison of Baseline and Proposed Action DNL Contours for AAD Aircraft Operations at RAAF Base Darwin
PACAF Australia ER

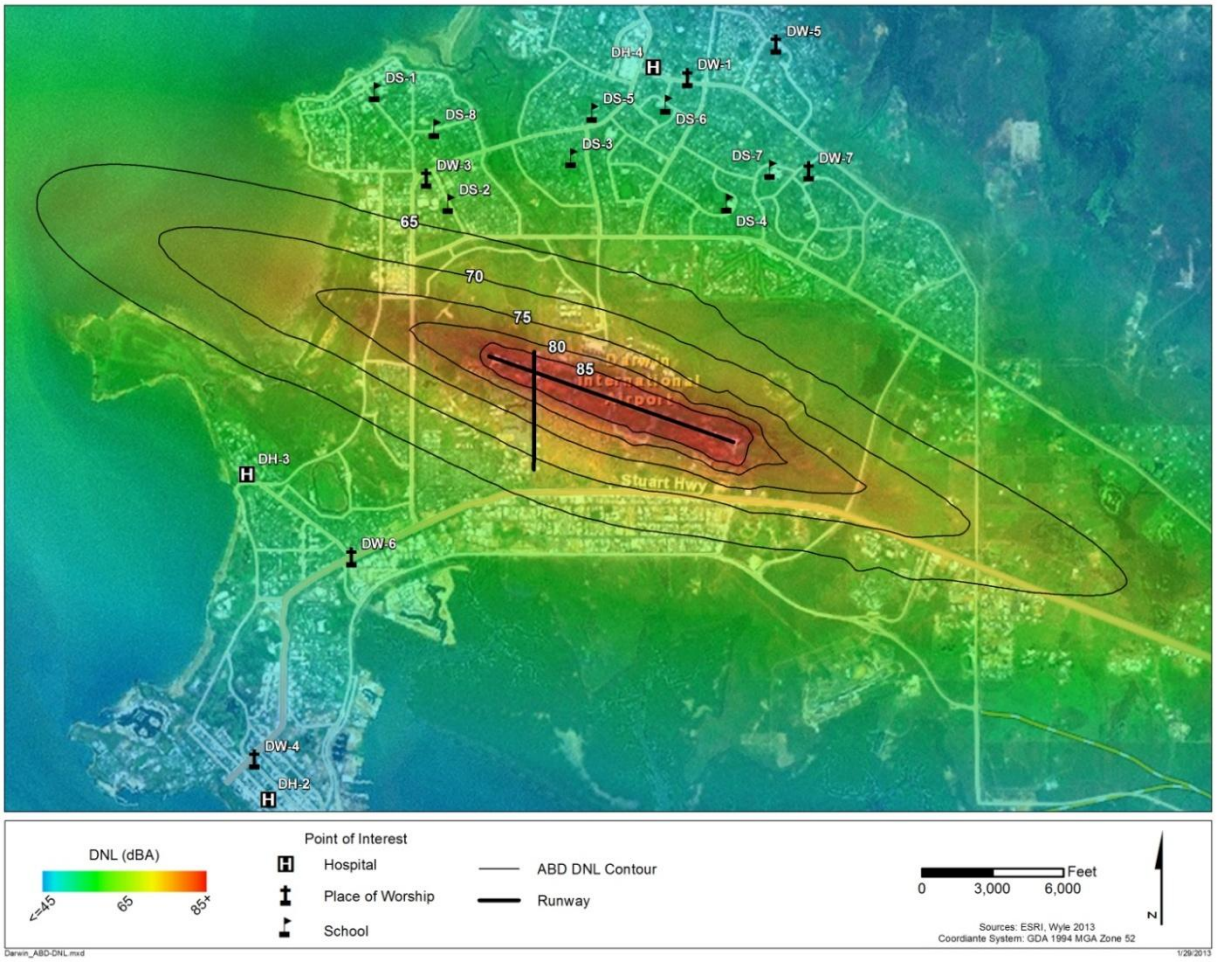


Figure 3-6
DNL Contours and Gradient for PACAF Exercise ABD Aircraft Operations at RAAF Base Darwin
PACAF Australia ER

Figure 3-7
Representative Points of Interest for RAAF Base Darwin
PACAF Australia ER

SECTION 4.0

RAAF Base Tindal Important Environmental Issues

This section presents information on the potential environmental issues that may result from USAF operations at RAAF Base Tindal. These issues were identified during a site visit to RAAF Base Tindal by PACAF engineers, AFCEC NEPA managers, and USAF environmental contractors on 12-15 November 2012. The information provided below is based on personal conversations with RAAF DSG environmental and estate managers, as well as documents provided during the meetings.

4.1 Utilities

4.1.1 Energy

Energy on RAAF Base Tindal is obtained via a high-voltage power line from the City of Darwin, 177 miles to the north. Once the electricity reaches the base, electrical service is provided by the RAAF Base Tindal base engineering operations contractor. The base has an emergency electrical generation capability.

According to David Marshal, Base Support Manager, DSG, RAAF Base Tindal, the base is operating on the edge of its available electrical capacity. USAF planners may want to plan on providing backup power for essential operations. The base has natural gas onsite that could be used for electricity generation, or diesel/JP8 fuel. If a tent city is sited on the golf course at RAAF Base Tindal, electricity is available nearby.

Impact Minimization: USAF planners will consider supplying backup electrical generation during training exercises.

Electricity availability is not expected to be a major problem during construction or during conduct of the joint training exercises.

4.1.2 Drinking Water

Drinking water on RAAF Base Tindal is provided by the nearby community of Katherine. The Katherine water supply is a mixture of water from the Katherine River and bores (wells). Groundwater recharge for the bores (wells) is thought to originate from the area of RAAF Base Tindal. Therefore, protecting the groundwater recharge area on base from contamination is important to the local community. The water is treated, chlorinated, and piped approximately 6 miles (10 kilometers) to RAAF Base Tindal. Water interruptions have occurred periodically, primarily during the wet season when pipes break and the water treatment system is shut down to prevent contamination of the system. Drinking water distribution systems on RAAF Base Tindal are operated by the base operating contractor, and the USAF will have no responsibility in operating this drinking water system.

According to David Marshal, Base Support Manager, RAAF Base Tindal, the installation consumes approximately 1.3 million gallons (5 mega liters [ML]) of drinking water per day.

RAAF Base Tindal has a 1.6-million-gallon (6-ML) storage tank and chlorination unit. During periods of interruption, the base uses the water in the storage tank. If necessary, drinking water can be trucked to the installation. The base is currently converting irrigation systems to bore (well) water, which could reduce the facility's daily drinking water consumption. This drinking water system has supported exercises involving more than 2,000 temporary personnel in addition to the 1,200 personnel stationed on the base. Therefore, with the PACAF planning factor of 340 USAF personnel for two 15-day joint training exercises, adequate drinking water should not be a problem. Bore (well) water may be used for construction.

Impact Minimization: Not applicable.

Adequate drinking water is not expected to be a problem during conduct of the joint training exercises.

4.1.3 Wastewater

Wastewater on RAAF Base Tindal is treated at the WWTP located on the south side of the installation. The treatment facility consists of aerated lagoons and spray irrigation in eight circular areas. The plant is designed to treat wastewater from a total of 3,100 personnel. The WWTP is operated by the RAAF Base Tindal operating contractor, and the USAF will have no involvement or responsibility in operating the facility.

The current resident population on Tindal RAAF is 1,200 military and family members. David Marshal, Base Support Manager, RAAF Base Tindal, indicated there were no reported problems with wastewater treatment during previous training exercises involving more than 2,000 transient personnel. However, the capacity of the WWTP could possibly be expanded, if necessary, with the addition of a mechanical aerator. The USAF is planning for only 340 USAF personnel to take part in the two 15-day joint training exercises. The WWTP will be treating wastewater from less than 1,600 personnel (1,200 resident RAAF members and 340 temporary USAF personnel) during the training exercises, well below the designed wastewater treatment capacity of 3,100 personnel.

Impact Minimization: Not applicable.

Wastewater treatment is not expected to be a problem during construction or during conduct of the joint training exercises.

4.1.4 Solid Waste

Solid waste on RAAF Base Tindal is collected by an off-base contractor and transported to a solid waste disposal facility in Katherine. The solid waste disposal contract is managed by the DSG RAAF Base Tindal base engineering operations contractor, and the USAF will have no responsibility in managing this contract. According to David Marshal, Base Support Manager, RAAF Base Tindal, the disposal of the additional solid waste from previous training exercises has not been a problem. Recycling is important to RAAF Base Tindal and the local community, and will be emphasized to units participating in joint training exercises. Types of source separation (such as food/wet waste, plastic, metal, and paper) will be discussed as part of exercise planning because recycling rules may change over time. Sufficient containers for the waste separation will be addressed as part of exercise planning.

Hazardous waste disposal is discussed in Section 4.3, *Hazardous Material and Hazardous Waste,* of this document.

Impact Minimization: When planning for exercises, coordination with the solid waste disposal contractor for additional trucks or frequency of removal will be conducted as necessary. Recycling will be a priority.

Solid waste disposal is not expected to be a problem during construction or during conduct of the joint training exercises.

4.2 Water Quality

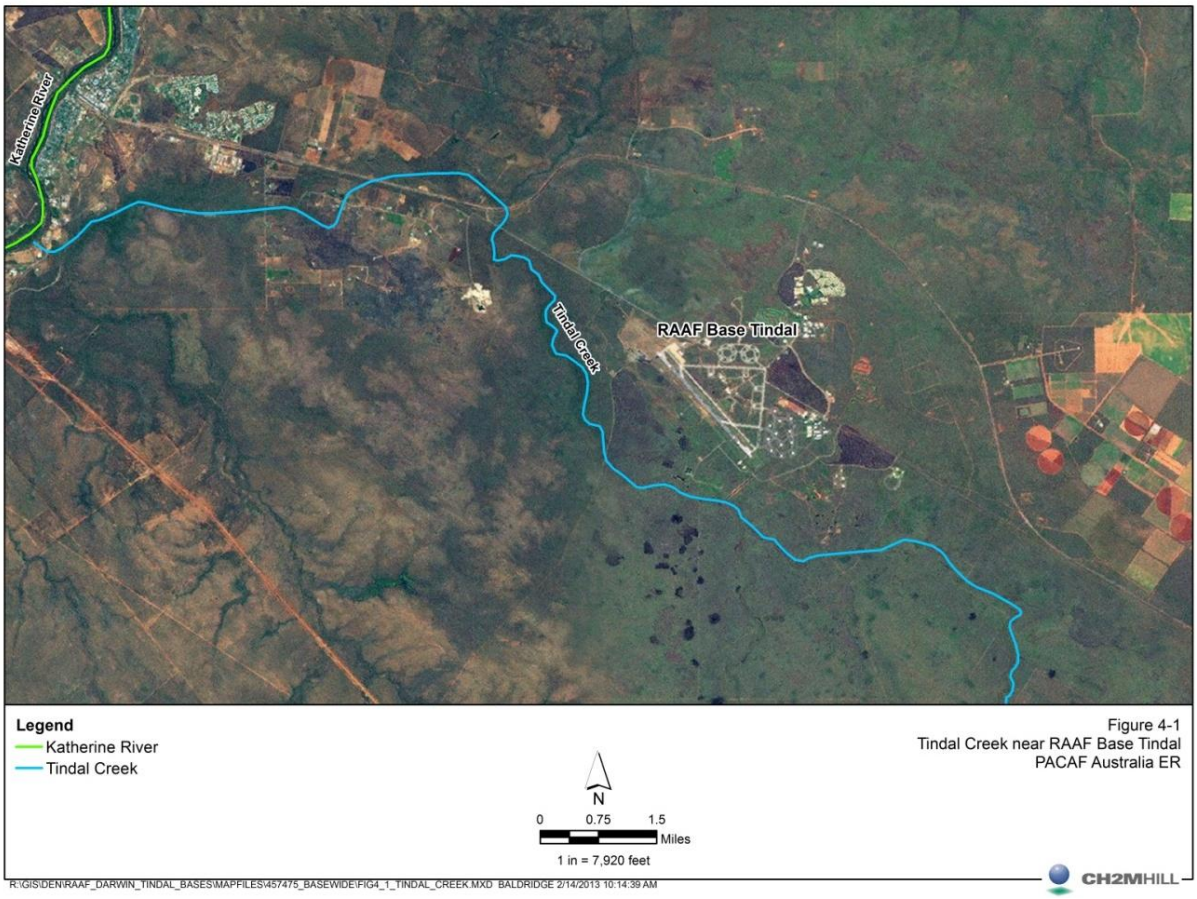
4.2.1 Surface Water

Most of RAAF Base Tindal lies within the Tindal Creek catchment area. Tindal Creek is an ephemeral tributary of the Katherine River, which is located approximately 12 miles (20 kilometers) south of the base (**Figure 4-1**). Tindal Creek is typically dry between May and November.

The Katherine River is a primary source of water for the town of Katherine and RAAF Base Tindal, and is a major concern to the local community. Stormwater from the airfield drains toward Tindal Creek and ultimately the Katherine River (SKM, 2001). The proposed USAF activities could impact water quality of Tindal Creek catchment areas by increasing the risk of fuel spills, the addition of impervious area, and runoff from construction.

Impact Minimization: Stormwater runoff from construction activities and the increased impervious area will be addressed in the design of all proposed capital improvement projects. BMPs, such as the installation of oil/water separators near refueling areas, will also be put in place to prevent fuel spills from reaching Tindal Creek.

Impacts to Tindal Creek will likely be an issue during the RAAF Siting Board, and it is important BMPs are included in facility designs. Potential BMPs include oil/water separators and a dyke network of containment systems.



4.2.2 Groundwater/ Sinkholes

RAAF Base Tindal is built on a limestone landscape, which is responsible for numerous sinkholes found onsite. The sinkholes are formed by groundwater eroding limestone rock underlying the surface. Many sinkholes have been identified on the south side of the airfield (**Figure 4-2**), and new sinkholes are constantly being formed through the movement of groundwater (SKM, 2007). Due to the hydrogeology within the area of RAAF Base Tindal, groundwater is the most significant pathway for soil and water contamination to reach potentially sensitive receptors (AECOM, 2009). Any spills occurring in the southern portion of the airfield would likely enter the sinkholes and directly impact groundwater.

Impact Minimization: Sinkholes will be accounted for during the siting phase of any capital improvement facilities. In addition, BMPs, such as a dyke network, will be put in place to prevent any spills from entering the sinkholes on the south side of the airfield.

Sinkholes could be an issue during USAF-sponsored construction activities and during conduct of the joint training exercises. It is important that precautions are taken to avoid construction near sinkholes, and that BMPs are put in place to prevent spills from entering the sinkholes.

Figure 4-2
Sinkholes on RAAF Base Tindal
PACAF Australia ER

4.3 Hazardous Material and Hazardous Waste

4.3.1 Existing Contamination

A review of the history of RAAF Base Tindal as well as the installation's current uses identified the following activities that may have contaminated soil and or groundwater on the facility (AECOM, 2009):

- Use of aldrin up until 1988;
- Uncontrolled dumping of waste in various landfills and burial sites;
- Burial of crashed aircraft;
- Detonation of expired ordnance;
- Leaks from underground storage tanks;
- Fuel or chemical spills;
- Discharge of contaminated wastewater; and
- The old base sewage system.

Many of the potentially contaminated sites are located in the vicinity of the airfield. Consequently, airmen and contractors working on the installation should remain vigilant and report any areas contaminated with suspected hazardous material to RAAF DSG personnel.

Impact Minimization: Personnel working on RAAF Base Tindal will report the discovery of any contaminated areas to RAAF DSG personnel.

Impacts from existing contamination are not expected to be a problem during construction or during conduct of the joint training exercises.

4.3.2 Hazardous Material Handling and Management

The handling and management of hazardous material are significant issues at RAAF Base Tindal. Apart from catastrophic events such as aircraft accidents, the largest potential for soil, surface water, and groundwater contamination during normal base operations results from the storage and handling of aviation fuel. This is a particular concern on RAAF Base Tindal because fuel spills near sinkholes would directly affect groundwater.

Other hazardous substances stored at RAAF Base Tindal include bulk liquid oxygen, bulk liquid nitrogen, liquid petroleum gas in tanks and cylinders, oxygen, acetylene, compressed air, argon, solvents, paints, sodium hypochlorite, and chemical maintenance substances (SKM, 2000). Generally, hazardous waste is containerized and transported by contractors to Adelaide, located on the south-central coast of Australia.

The only unique hazardous materials the USAF will transport when deploying to Australia is hydrazine. Otherwise, the hazardous materials utilized will be standard petroleum, oils, and lubricants currently used on Australian aircraft. Hydrazine was of specific concern to the RAAF DSG. Hydrazine is a highly toxic and flammable propellant used in F-16 aircraft. Hydrazine is not currently used by the RAAF, although it has been used by other nations operating on RAAF Base Tindal that fly F-16 aircraft.

Impact Minimization: Hazardous material and hazardous waste management plans will be created specifically for RAAF Base Tindal. All hazardous material used by the USAF will be

handled in accordance with U.S. DoD operating procedures and regulations, including AFJMAN 23-209, *Storage and Handling of Hazardous Materials*. Specifically, all hazardous material dispensing areas will be properly maintained, drums/containers must not be leaking, drip pans/absorbent materials will be placed under containers as necessary to collect drips or spills, container contents will be clearly marked, and all personnel handling the hazardous material will be properly trained. Additionally, a hazardous waste accumulation point will be operated to provide appropriate segregation of different waste streams. When available, USAF will use established RAAF hazardous waste accumulation points. Hydrazine will be handled in accordance with established neutralization procedures (Technical Order 1F-16C-2-49GS-00-1).

The use and management of hazardous materials were the most significant environmental issues identified by RAAF environmental personnel during the site visit. It is important that the USAF adheres to its established guidance documents, and that appropriate BMPs are put in place to reduce the likelihood of a spill reaching Tindal Creek or a sinkhole.

4.4 Transportation

Ground transportation to RAAF Base Tindal is by way of Stuart Highway, which connects Darwin to Adelaide. Most material is shipped into the Port of Adelaide & Brisbane and trucked by road train to the town of Katherine and RAAF Base Tindal. Stuart Highway is generally a two-lane highway with frequent passing lanes designed for traffic to pass heavy, slow-moving trucks. This highway connects sparsely populated areas throughout the central part of Australia.

According to David Marshal, Base Support Manager, RAAF Base Tindal, the anticipated additional truck traffic needed to support the USAF joint training exercises will have minimal effect to traffic on Stuart Highway. Large training exercises conducted in the past have had minimal impact on Stuart Highway traffic, and previous construction projects on RAAF Base Tindal have had no apparent effect on highway traffic. USAF personnel should be transported by bus or truck if they go off base during exercises. The additional number of vehicles resulting from the joint training exercises is expected to have minimal impact both on and off base.

Impact Minimization: USAF personnel will have limited access to personal vehicles while onsite and will rely on RAAF-provided buses or rental buses/trucks when available.

Traffic is not expected to be a problem during construction or during the joint training exercises.

4.5 Air Quality and Greenhouse Gases

The primary pollutants of concern in the Northern Territory are from particulates (PM_{10}, $PM_{2.5}$) and GHG pollutants. However, the overall air quality in the Katherine region would be considered unclassified by U.S. standards, and air quality was not a resource of concern for RAAF Base Tindal DSG personnel.

Sources and Thresholds

The scale and duration of construction at RAAF Base Tindal will be a source of short-term, temporary emissions, and construction emissions will be significantly less than the emission resulting from operation of the training activities, which are quantified below. Therefore, only the emissions associated with the joint training exercises were quantified to determine the relative impact to air quality in the region.

Joint exercise emission sources will include aircraft, fueling/ground equipment, commercial buses (personnel transportation), fuel transfer operations, on-the-ground stationary combustion equipment, and fuel storage tanks. It is assumed that the primary source of emissions will be from the combustion of fuel in aircraft, and that the other sources will be minor relative to these emissions. The total fuel combusted per aircraft engine was used in conjunction with the AFCEE Mobile Guide to estimate the operational emissions (AFCEE, 2009). Aircraft emissions include the following components: approach, takeoff, and climb out (idle time was not included in accordance with the AFCEE Mobile Guide because it is not a part of standard training activities). These estimated emissions were compared to the relative thresholds identified below to determine if air quality in the region would be impacted.

Because the Northern Territory is the equivalent of a U.S. attainment or unclassified area, the proposed thresholds of significance for criteria pollutants are the General Conformity thresholds for an attainment or unclassified area, which is 100 tons per year. In Australia, the national reporting framework for GHG is the NGER. The facility-level reporting is 25,000 MT, which is similar to the U.S. CEQ guidance; however, this does not necessarily indicate a significant impact. If the GHG emissions are likely to be greater than 25,000 MT of CO_2e, the emissions were quantified. The environmental issues associated with ambient air quality and GHGs are discussed in the following sections.

4.5.1 Ambient Air Quality

There is no specific evaluation of the air quality near RAAF Base Tindal because the Katherine area is under the necessary population thresholds for monitoring. Therefore, the Katherine area would be considered unclassified by U.S. standards.

Based on 2010 – 2011 inventory data, the RAAF is not currently required to obtain air permits or register as a part of the NPI (NPI, 2012b). This is consistent with requirements in the United States, where military aircraft engines are exempt from the federal aircraft engine NO_x emissions standards in 40 CFR 87 and are not subject to permitting requirements or other federal stationary or mobile source emissions standards or regulations.

Emissions associated with the proposed training exercises were quantified based on project-specific data for equipment type and fuel usage, which was done in accordance with the methodology and emission factors in the *Air Emission Factor Guide to Air Force Mobile Sources* (AFCEE, 2009). As shown in **Table 4-1**, the estimated emissions for the aircraft training operations at RAAF Base Tindal are all less than 100 tons per year for U.S. criteria pollutants. Details of the air emission calculations are included in **Appendix A**.

Table 4-1
Estimated Emissions for Aircraft Training Operations, RAAF Base Tindal
PACAF Australia ER

Aircraft Type	Emissions (ton/year)				
	NOx	CO	VOC	PM_{10}	$PM_{2.5}$
Bomber (B-52)	23	12	4	1	1
Tanker (KC-135)	29	13	0.1	0.4	0.3
Fighter (F-22)	25	16	1	5	4
UAV	1	1	0.03	0.2	0.2
Tindal Aircraft Total Annual Criteria Emissions:	**78**	**42**	**5**	**7**	**6**

Notes: Numbers in columns may not add up exactly due to rounding.

The primary air quality issue in the Northern Territory is from dust, or particulate matter. The significance threshold used for this project is 100 tons per year. The estimated particulate emissions associated with the increased training activities are less than 10 tons per year, which is substantially lower than the 100-ton-per-year threshold. Therefore, because the emissions estimated from the additional training activities are much lower than the threshold of significance, it is not likely that the additional training will create an environmental impact to air quality in the region. However, prevention of dust emissions during construction is advised.

Impact Minimization: The use of standard BMPs, such as watering bare areas, to control dust emissions will be used during construction.

Ambient air quality should not be an issue during construction or during conduct of the joint training exercises.

4.5.2 Greenhouse Gas

The two components of the NGER Scheme that relate to the RAAF are the GHG reporting thresholds and carbon pricing mechanism (NGER, 2012a). RAAF Base Tindal was not listed as a registered GHG reporter for fiscal year 2010 – 2011 (NGER, 2012c). Therefore, the RAAF is not considered one of "Australia's biggest polluters" of GHGs, and will not have to pay a price for its carbon emissions.

The GHG emissions associated with the combustion of fuel from aircraft during training exercises were quantified to provide an estimate of the impact of GHG emissions. These emissions at RAAF Base Tindal were approximately 25,600 MT CO_2e. Although those emissions are just slightly above the NGER facility threshold of 25,000 MT CO_2e, the installation is taking steps to decrease its carbon footprint at RAAF Base Tindal, which would reduce the installation's impact to climate change through the generation of fewer GHG emissions. Furthermore, because these sources are not stationary sources, they would likely still not be considered a major source of GHG pollutants because most of the regulations are aimed at reducing stationary source emissions.

Impact Minimization: Not applicable.

GHG emissions should not be an issue during construction or during conduct of the joint training exercises.

4.6 Biological Resources

4.6.1 Sensitive Species

Of the 21 Australian species listed as threatened or endangered in the ESA, only the saltwater crocodile's range occurs on RAAF Base Tindal, although it is listed as a species of least concern under the *Territory Parks and Wildlife Conservation Act.* Airmen and contractors will be made aware of the protected status of the species in the United States and warned, for their own protection, to avoid the species and its habitat.

The region around RAAF Base Tindal has 30 EPBC-listed species and 50 species listed as threatened in the Northern Territory (Northern Territory, 2011). There are no listed plant species on RAAF Base Tindal; however, some endemic plant species are present in the region, including vegetation on limestone outcrops and mesophyll vine forests found in sinkholes. Some sensitive animal species have been found on RAAF Base Tindal, including the red goshawk (*Erythrotriorchis radiatus),* which is EPBC-listed as vulnerable. Termite mounds are also prevalent throughout the Katherine/RAAF Base Tindal area, and are a significant feature of the local ecosystem (SKM, 2001).

The airfield and surrounding area are heavily developed and disturbed; therefore, the likelihood of USAF operations affecting sensitive species is remote. RAAF Base Tindal environmental personnel regularly monitor the airfield for sensitive species and have seen no need to perform sensitive species surveys in response to the Proposed Action.

Although it is unlikely USAF operations would impact ESA- or EPBC-listed species, all Australian native vertebrate animals living in the Northern Territory are protected under the *Territory Parks and Wildlife Conservation Act of 2009*. Therefore, it is important that USAF operations do not harm native Australian vertebrates.

Impact Minimization: Airmen and construction contractors will be informed of the protected status of all Australian vertebrates and advised to avoid harming any animals. If a sensitive species is identified by RAAF personnel in the vicinity of the Proposed Action, operations will cease and measures will be taken under the guidance of RAAF DSG personnel to avoid harming the organism.

Construction and operation activities are not expected to impact sensitive species.

4.6.2 Biosecurity

The natural landscapes of the Northern Territory are largely still intact due to the relative isolation and remoteness (Northern Territory, 2011). Consequently, exotic weeds, pests, and diseases can have devastating effects on soil, native vegetation, wildlife, crops, and livestock. Insects are the pest that poses the greatest potential of risk to the Northern Territory.

DAFF manages quarantine controls to minimize the risk of exotic pests and diseases entering the country. DAFF develops procedures and provides services to ensure adequate quarantine and inspection occurs for all vessels, aircraft, vehicles, machinery, goods, cargo,

and personal effects entering Australia from foreign nations. The RAAF, along with a number of other regional organizations, have developed plans to control the spread of exotic species (RAAF, 1999; Northern Territory, 2011).

The United States normally asserts the privilege of sovereign immunity for all U.S. State aircraft and vessels, and thus does not consent to the boarding and inspection of such aircraft and vessels by foreign government authorities. However, satisfaction of Australia's biosecurity requirements is essential to control the risks posed by weeds, pests, and diseases. Further, Article 13 of the 1963 Agreement between the Government of the Commonwealth of Australia and the Government of the United States of America concerning the Status of United States Forces in Australia states that the U.S. Government shall conform to Australian laws and regulations, including quarantine laws. Consequently, all USAF aircraft, equipment, and food supplies (including MREs) will need to undergo a quarantine process prior to operations in Australia.

Impact Minimization: The USAF will conform to the policy and procedures agreed to by DAFF, U.S. DoD and the USDA for the Talisman Sabre exercise in 2013. This policy regarding biosecurity was developed by the U.S. Embassy in Australia and USPACOM for sovereign immune assets (U.S. vessels and aircraft) entering Australia for the Talisman Sabre combined military exercises on mainland Australia. The U.S. does not normally assert sovereign immunity for U.S. machinery, vehicles, goods, cargo, or personal effects that are off-loaded from a U.S. aircraft or vessel. Unless sovereign immunity is specifically asserted, such items will undergo normal DAFF-approved biosecurity inspections upon arrival into Australia or by special arrangement prior to departure for Australia.

Biosecurity is a very important issue in Australia because the country is relatively free of many of the animal and plant diseases affecting other nations. If the USAF conforms to the 2013 Talisman Sabre quarantine agreements, biosecurity should not be a problem during construction or during conduct of the joint training exercises.

4.7 Wildfire

Historically, at least one wildfire occurs on RAAF Base Tindal each year, usually during the dry season. The installation manages its own fire management program and has dedicated fire crews (GHD, 2008). The current fire regime consists of a series of annual infrastructure and boundary protection burns undertaken in May/June, and firebreaks around the airfield boundary (RAAF Base Tindal, 2001).

Impact Minimization: Not applicable.

Wildfires are not expected to be a problem during construction or during conduct of the joint training exercises.

4.8 Heritage

4.8.1 Aboriginal Heritage

Aboriginals have long used the Katherine/RAAF Base Tindal area as a hunting and gathering region. Many plant and animal species in the area have been, and still are, a favored part of the local Aboriginal diet (SKM, 2001). The most likely areas to contain

archaeological sites are along watercourses and around rock outcrops. Forty-nine Aboriginal archaeological sites have been identified within the RAAF Base Tindal perimeter (AECOM, 2012), all of which are located away from the airfield and potential capital improvement sites, including the golf course.

Impact Minimization: Given the extent of clearing and ground disturbance in the airfield and golf course areas, it is unlikely that new Aboriginal heritage sites would be found in the vicinity of any construction or operation areas. However, if any artifacts are discovered during construction, all activities at the site will cease and the RAAF DSG contacted. RAAF DSG will manage the site in accordance with Australian regulatory requirements.

Impacts to Aboriginal heritage sites are not expected to be a problem during construction or during conduct of the joint training exercises.

4.8.2 European Heritage

Although the airfield at RAAF Base Tindal was originally constructed in 1942 in response to Japanese aggression in the region, no aircraft were stationed there until 1988. The original airfield was rebuilt in the 1970s (Air Force, n.d.). Consequently, there are limited historic heritage sites located on the base.

Impact Minimization: Not applicable.

Impacts to European heritage sites will not be a problem during construction or during conduct of the joint training exercises.

4.9 Health and Safety

4.9.1 Wildlife Strikes

Wildlife can pose a significant hazard to the safe conduct of aircraft operations. The vast majority of bird or wildlife strikes occur either on or within the immediate proximity of a runway, and in many of those events, damage is sustained to the aircraft. In serious incidents, damage from a strike could result in the aircraft being unable to maintain safe operations.

RAAF Base Tindal has an ongoing wildlife strike mitigation plan. Wildlife deterrents on the installation include:

- Removal of roosting sites;
- Removal of pools and depressions;
- Removal of waste;
- Removal of tall vegetation; and
- Education of base personnel (Kinhill Engineers, 1987).

Impact Minimization: The USAF will report any wildlife strikes to the RAAF DSG, so that the RAAF can properly manage its bird strike program.

RAAF Base Tindal has an ongoing wildlife strike management program and, therefore, bird or wildlife strikes should not be a significant problem during the joint training exercises.

4.9.2 Insect-Borne Disease

Mosquito-borne diseases of concern around RAAF Base Tindal mainly originate from Asia and include Ross River virus, Barmah Forest virus and Murray Valley encephalitis. RAAF Base Tindal has an ongoing mosquito management strategy. Surveys at RAAF Base Tindal identified potential breeding sites for pests and disease-carrying mosquito species. Potential breeding sites include the network of open unlined drains, the sewage ponds, and borrow pits. Various artificial water-holding receptacles, such as tires and drums, are also potential breeding sites (SKM, 2001).

The period of greatest mosquito activity in the Northern Territory is during the wet season in December and January (Northern Territory Department of Health, 2012), and not during the expected period for the joint training exercises. Nonetheless, mosquitoes are present outside this period and measures will be taken to reduce the likelihood of mosquito bites.

Impact Minimization: USAF personnel will implement the following personal protection measures while in the Northern Territory to reduce the risk of contracting and spreading insect-borne illnesses:

- Avoid areas known to have high mosquito activity;
- Remain inside insect-screened buildings when possible;
- Use mosquito nets at temporary camps or unscreened buildings;
- Use repellents containing DEET;
- Avoid the use of white light at campsites (Northern Territory Department of Health, 2011) ; and
- Treat uniforms with permethrin.

Insect-borne diseases should not be a problem during exercises; however, precautions will be taken to avoid bites by mosquitoes.

4.9.3 Unexploded Ordnance (UXO)

Inadvertent discovery of UXO on RAAF Base Tindal is possible but not likely, according to David Marshal, Base Support Manager, RAAF Base Tindal. Because the possibility exists, however, precautions will include making all construction and USAF personnel aware of the potential for UXO discovery. If a fragment of UXO or suspected UXO is discovered, personnel will be directed to stop work, leave the ordnance untouched, evacuate the area, and contact RAAF personnel.

Impact Minimization: UXO training as prescribed by RAAF Base Tindal and PACAF will be provided to appropriate construction and USAF personnel to reduce risks associated with potential UXO contact.

UXO is not expected to be a major issue during construction or during conduct of the joint training exercises.

4.10 Noise

The methodology for analyzing RAAF Base Tindal was the same as for RAAF Base Darwin (Section 3.10). However, baseline data were not available for RAAF Base Tindal. Therefore, comparison could not be made between the Baseline and the Proposed Action. The AAD

DNL, shown in **Figure 4-3**, includes the PACAF exercises only and, thus, is artificially small because it disregards based military aircraft (including fighters) at RAAF Base Tindal. The ABD DNL is shown in **Figure 4-4**.

Noise exposure was computed for five POIs (one hospital, two schools, and two places of worship) near Katherine, which is approximately 10 miles (16 kilometers) from RAAF Base Tindal. The POIs are shown in **Figure 4-5** with noise levels listed in **Table 4-2**.

RAAF Base Tindal is located away from populated areas and noise sensitive areas, including aboriginal communities. No POI will experience an ABD DNL above 45 dB. Additionally, noise events at the POI will only exceed 70 dB for a fraction of a minute per day. This indicates that PACAF exercises may be noticeable above ambient noise levels in Katherine if only for a short duration. Noise exposure due to the proposed exercises will not cause significant impacts to the region surrounding RAAF Base Tindal or to the town of Katherine. Further, minimal impacts to wildlife are expected as animal populations residing in the effected region are accustomed to aircraft noise and the minimal increase should not result in a noticeable increase in disturbance compared to current conditions.

Noise contour maps of Lmax, NA, TA, and ANEF are presented in **Appendix B**.

Impact Minimization: Aircraft will be operated in compliance with aircraft operating and local noise abatement procedures. Current rules restrict fighters from departing after 10 PM.

The proposed PACAF exercises at RAAF Base Tindal will not cause significant noise impacts based on USAF policy.

Table 4-2
POI Noise Exposure for ABD Aircraft Operations at RAAF Base Tindal
PACAF Australia ER

PIO				NA (events)			TA (minutes)		
ID	Description	DNL (dB)	Lmax (dB)	70 dB Lmax	85 dB Lmax	100 dB Lmax	70 dB Lmax	85 dB Lmax	100 dB Lmax
TH-1	Katherine Hospital	<45	74	<1	0	0	0.4	0	0
TS-1	St. Joseph's College	<45	69	0	0	0	0	0	0
TS-2	Katherine High School	<45	74	<1	0	0	0.2	0	0
TW-1	Anglican Church of Australia	<45	67	0	0	0	0	0	0
TW-2	Heritage Christian Church	<45	79	<1	0	0	0.4	0	0

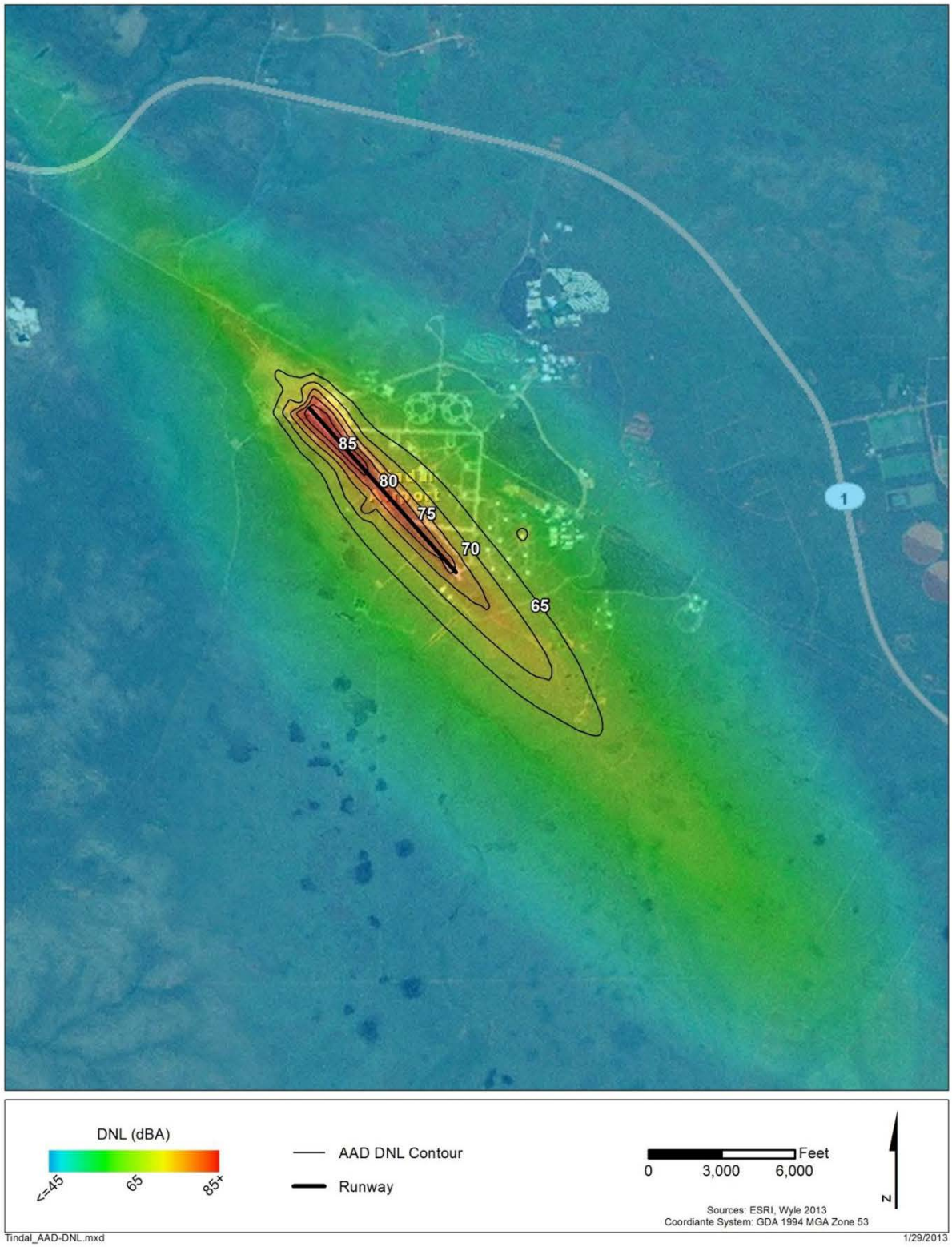


Figure 4-3
DNL Contours and Gradient for PACAF Exercise AAD Aircraft Operations at RAAF Base Tindal
PACAF Australia ER

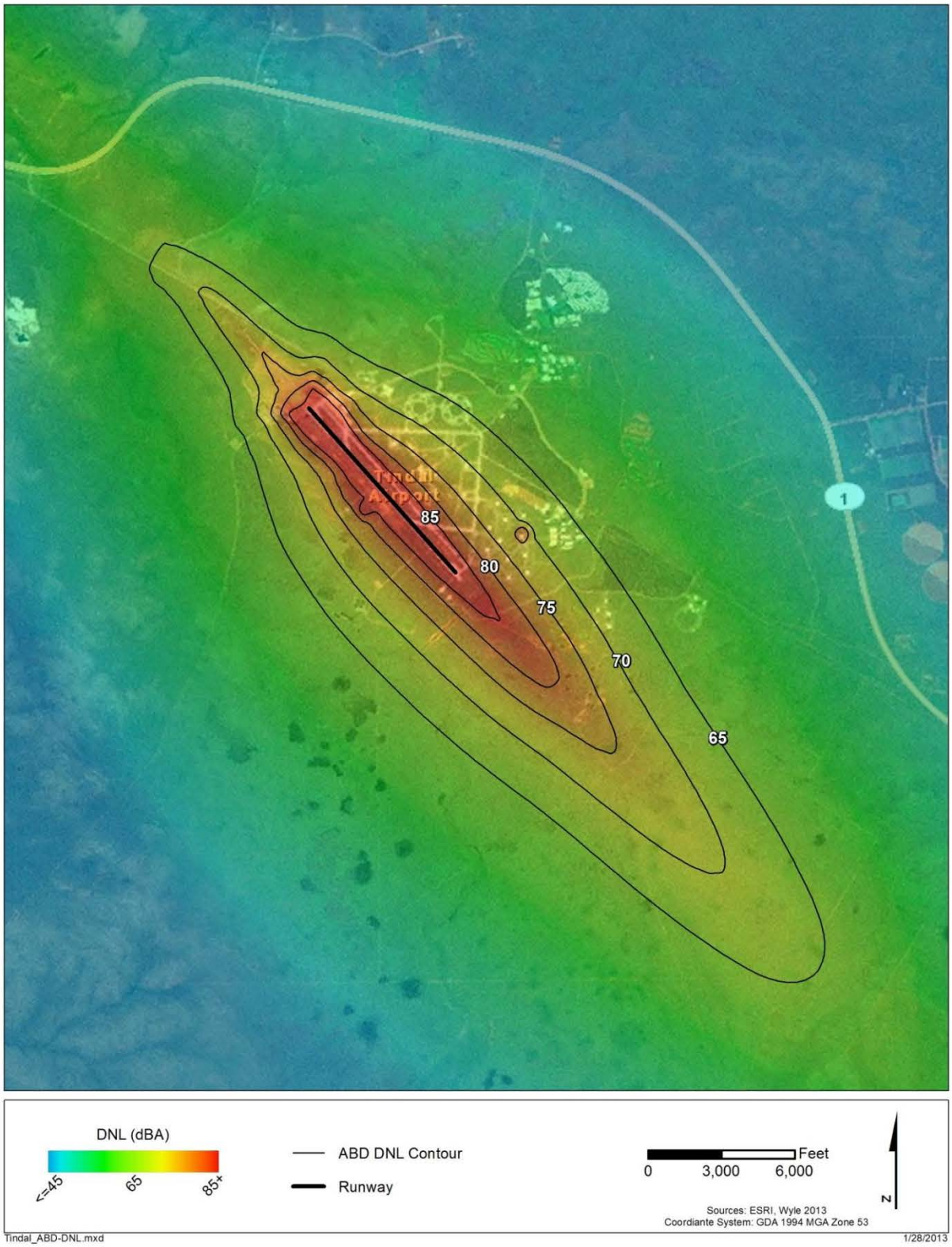


Figure 4-4
DNL Contours and Gradient for PACAF Exercise ABD Aircraft Operations at RAAF Base Tindal
PACAF Australia ER

Figure 4-5
Representative Points of Interest for RAAF Base Tindal
PACAF Australia ER

SECTION 5.0

Summary of Impact Minimization Measures

Table 5-1 provides a summary of the environmental issues resulting from USAF operations at RAAF Bases Darwin and Tindal, and the associated impact minimization measures.

Table 5-1
Impact Minimization Summary Table
PACAF Australia ER

Environmental Issue	Impact Minimization Measure or BMP
RAAF Base Darwin	
Utilities	
The base is currently operating at the edge of its current electrical capacity.	Supply backup electrical capacity during exercises, if necessary.
Solid waste management and recycling are important issues to the RAAF.	When planning for exercises, USAF personnel will coordinate with the Estate Manager for additional solid waste trucks. Recycling will be a priority.
Water Quality	
Stormwater runoff could impact Rapid Creek.	Stormwater BMPs will be included in the design of any proposed capital improvement facilities.
Fuel spills could enter Rapid Creek.	BMPs will be implemented to prevent spills from entering Rapid Creek and USAF units will implement spill prevention measures.
Hazardous Materials and Hazardous Waste	
Potential discovery of contaminated landfills during construction.	If a landfill is discovered, operations will cease and the RAAF DSG will be contacted immediately and allowed to manage the cleanup.
Use of hazardous materials and waste generation.	All USAF activities will follow established U.S. DoD guidelines.
The use of hydrazine is a specific concern to the RAAF DSG.	Handle hydrazine in accordance with established neutralization procedures (Technical Order 1F-16C-2-49GS-00-1).
Transportation	
Increased traffic could negatively affect the installation's transportation infrastructure.	USAF personnel will be transported by bus during the period of the joint training exercise, whenever possible and the use of personal vehicles will be limited.
Air Quality and Greenhouse Gases	
Increased dust emissions during construction activities	Standard dust control BMPs such as watering bare ground will be implemented during construction.

Table 5-1
Impact Minimization Summary Table
PACAF Australia ER

Environmental Issue	Impact Minimization Measure or BMP
Biological Resources	
Impacts to protected Australian wildlife.	Airmen and construction contractors will be informed of the protected status of all Australian vertebrates and advised to avoid harm to any animals.
Potential introduction of organisms exotic to Australia.	USAF will conform to the policy and procedures agreed on during the 2013 Talisman Sabre exercises.
Heritage	
Disturbance to a previously unidentified archaeological site.	If artifacts are discovered, operations will cease and DSG personnel will be contacted.
A negative effect on the historic character of RAAF Base Darwin.	New facilities will follow the RAAF Base Darwin Master Plan (Woods Bagot, 2009).
Health and Safety	
Potential wildlife strikes by aircraft.	Report any incidents to the RAAF DSG.
Disease-carrying insects may be present during exercises and construction.	Take precautions to avoid being bitten as outlined by the Northern Territory Department of Health.
Inadvertent discovery of UXO during construction.	Cease operations and notify the RAAF DSG.
Noise	
Increased noise to surrounding community.	Aircraft will be operated in compliance with aircraft operating and local noise abatement procedures. Current rules restrict fighters from departing after 10 PM.
RAAF Base Tindal	
Utilities	
The base is currently operating at the edge of its current electrical capacity.	Supply backup electrical capacity during exercises, if necessary.
Solid waste management and recycling are important issues to the RAAF.	When planning for exercises, coordinate with the Estate Manager for additional solid waste trucks. Recycling will be a priority.
Water Quality	
Stormwater runoff could impact Tindal Creek.	Stormwater BMPs will be included in the design of any capital improvement facilities.
Fuel spills could enter Tindal Creek or groundwater.	BMPs will be implemented to prevent spills from entering Tindal Creek or sinkholes and USAF personnel will implement spill protection measures.
Hazardous Materials and Hazardous Waste	
Potential discovery of contaminated areas during operations.	If a contaminated area is discovered, the DSG will be contacted immediately and allowed to manage the cleanup.

Table 5-1
Impact Minimization Summary Table
PACAF Australia ER

Environmental Issue	Impact Minimization Measure or BMP
Use of hazardous materials and waste generation.	All USAF activities will follow established U.S. DoD guidelines.
The use of hydrazine is a specific concern to the RAAF DSG.	Handle hydrazine in accordance with established neutralization procedures (Technical Order 1F-16C-2-49GS-00-1).
Transportation	
Increased traffic could negatively affect the installation's transportation infrastructure.	USAF personnel will be transported by bus during the period of the joint training exercise, whenever possible and the use of personal vehicles will be limited.
Air Quality and Greenhouse Gases	
Increased dust emissions during construction activities	Standard dust control BMPs, such as watering bare ground, will be implemented during construction
Biological Resources	
Impacts to protected Australian wildlife.	Airmen and construction contractors will be informed of the protected status of all Australian vertebrates and advised to avoid harm to any animals. If a sensitive species is identified by RAAF personnel in the vicinity of the Proposed Action, operations will cease and measures will be taken under the guidance of RAAF DSG personnel to avoid harming the organism.
Potential introduction of organisms exotic to Australia.	USAF will conform to the policy and procedures agreed on during the 2013 Talisman Sabre exercises.
Heritage	
Disturbance to a previously unidentified archaeological site.	If artifacts are discovered, operations will cease and RAAF DSG personnel will be contacted.
Health and Safety	
Potential wildlife strikes by aircraft.	Report any incidents to the RAAF DSG.
Disease-carrying insects may be present during exercises and construction.	Take precautions to avoid being bitten as outlined by the Northern Territory Department of Health.
Inadvertent discovery of UXO during construction.	Cease operations and notify the RAAF DSG.
Noise	
Increased noise to surrounding community.	Aircraft will be operated in compliance with aircraft operating and local noise abatement procedures. Current rules restrict fighters from departing after 10 PM.

SECTION 6.0

Contributing Actions

The following is a list of the actions known to have been taken or planned by the Australian government, or other nation, that may affect environmental considerations. These actions are expected to have an additive effect on environmental resources within the region. However, due to the minimal environmental impact expected from the proposed action, the cumulative effect should be less than significant.

- In addition to the USAF operations detailed in this ER, Prime Minister Gillard and President Obama also agreed to the increased use of the Northern Territory by the U.S. Marine Corps (USMC) (White House, 2011). USMC operations began in April 2012 with a company-sized unit of 200 marines and are projected to increase to approximately 2,500 marines by 2017. Marines are expected to spend most of their time at the Mount Bundy and Bradshaw Training Areas (*Marine Corps Times*, 2012).

- The Australian military performs a number of large-scale multilateral training exercises annually. These exercises include operations such as Pitch Black and Talisman Sabre, in which the U.S. takes part. During these exercises, numerous Australian military facilities are utilized, including RAAF Bases Darwin and Tindal. Exercises such as Pitch Black and Talisman Sabre involve thousands of military personnel from various nations (Aurecon, 2012).

- RAAF Bases Darwin and Tindal are actively used facilities; therefore, the infrastructure on both bases is continually maintained and future development is planned. Detailed lists of proposed infrastructure projects on RAAF Base Darwin can be found in the RAAF Base Darwin Master Plan (Woods Bagot, 2009). The RAAF Base Tindal Master Plan, however, currently is being updated.

SECTION 7.0

Coordination

Individuals Consulted

Dale Clark	AFCEC/CZN
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Maj Aaron Ogden	AFLOA/JACE-FSC (PACAF)
Robyn Maurer	RAAF
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Leigh Gilligan	RAAF

Agencies Contacted

Not Applicable

SECTION 8.0

List of Preparers

The following individuals contributed to the preparation of this EA.

Table 8-1
List of Preparers
PACAF Australia ER

Name	Role	Education	Years of Experience
Michelle Rau	Project Manager/ Lead Author	M.B.A. B.S. Ecology and Evolutionary Biology	15
Paul Thies	Senior Technical Consultant	Ph.D. Civil and Environmental Engineering M.S. Water Resources B.S. Forestry	32
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Daniel Robinson	Noise Lead	M.S. Mechanical Engineering B.S. Mechanical Engineering	11
Joseph Czech	Noise Analysis	B.S. Aerospace Engineering	25
Tom Cheney	Technical Editor	B.A. English Literature	33

SECTION 9.0

Acronyms and Abbreviations

AAD	average annual day
ABD	average busy day
AAM	Advanced Acoustic Model
AAQ	ambient air quality
ADF	Australian Defence Force
AFCEC	Air Force Civil Engineer Center
AFCEC Mobile Guide	*AFCEC Air Emissions Factor Guide to Air Force Mobile Sources*
AFH	Air Force Handbook
AFI	Air Force Instruction
AFJMAN	Air Force Joint Manual
AGE	aerospace ground equipment
AICUZ	Air Installation Compatible Use Zones
ANEF	Australian Noise Exposure Forecast
AOR	Area of Responsibility
AQIS	Australian Quarantine and Inspection Service
BEAR	Basic Expeditionary Airfield Resource
BMP	best management practice
BRA	bomber replenishment apron
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CITX	Citation X
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	CO_2 equivalents
DAFF	Department of Agriculture, Fisheries and Forestry
dB	decibels

1	dBA	A-weighted decibels
2	DIA	Darwin International Airport
3	DNL	Day-Night Average Sound Level
4	DNWG	Defense Noise Working Group
5	DoD	U.S. Department of Defense
6	DoDD	U.S. Department of Defense Directive
7	DoDI	U.S. Department of Defense Instruction
8	DSG	Defence Support Group
9	EBPC	Environment Protection and Biodiversity Conservation Act
10	EIS	environmental impact statement
11	EPNL	Effective Perceived Noise Level
12	ER	environmental review
13	FAA	Federal Aviation Administration
14	ft^2	square feet
15	GHG	greenhouse gas
16	INM	Integrated Noise Model
17	Lt. Col.	Lieutenant Colonel
18	Lmax	Maximum Sound Level
19	m^2	square meters
20	Maj.	Major
21	ML	mega liters
22	MRE	meal ready to eat
23	MT	metric ton
24	NA	Number of Events (at or) Above a Selected Threshold
25	NEPA	National Environmental Policy Act
26	NEPM	National Environment Protection Measure
27	NGER	National Greenhouse and Energy Reporting
28	NMAP	Noise Map
29	NO_x	oxides of nitrogen
30	NORFORCE	North-West Mobile Force

NPI	National Pollution Inventory
O_3	ozone
PACAF	U.S. Pacific Air Forces
PM_{10}	particulate matter less than 10 micrometers in aerodynamic diameter
$PM_{2.5}$	particulate matter less than 2.5 micrometers in aerodynamic diameter
PNdB	decibels of perceived noise
PNLT	Tone-Corrected Perceived Noise Level
POI	point of interest
RAAF	Royal Australian Air Force
SEL	Sound Exposure Level
SO_2	sulfur dioxide
TA	Times (at or) Above a Selected Threshold
U.S.	United States
UAV	unmanned aerial vehicle
USAF	U.S. Air Force
USDA	U.S. Department of Agriculture
USMC	U.S. Marine Corps
US PACOM	U.S. Pacific Command
U.S.T.	United States Treaties and other international agreements
UXO	unexploded ordnance
WHO	World Health Organization
WWII	World War II

SECTION 10.0

References

AECOM. 2009. *Stage 2 (Part III) Environmental Investigation RAAF Base Tindal, Draft Final*. 30 September.

AECOM. 2012. RAAF Base Tindal Archeological Indigenous Heritage Audit. 9 July.

AFCEE. 2009. *AFCEE Emissions Factor Guide to Air Force Mobile Source*. December 2009. Available at: https://afkm.wpafb.af.mil/DocView.asp?DocID=7808690.

Air Force (The Official Newspaper of the RAAF). n.d. *Features, Tindal: A History.* Available at: http://www.defense.gov.au/news/raafnews.

Australia. 1999. *Environmental Protection and Biodiversity Conservation Act of 1999.*

Australia. 2013. *Biodiversity and Threats Database, Crocodylus porosus*. Accessed 28 January 2014. Available at*: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1774.*

U.S. Code of Federal Regulations (CFR). 2012. 32 CFR Part 187, *Environmental Effects Abroad of Major Department of Defense Actions*. 1 July.

CFR. 2012. 32 CFR 989, Environmental Impact Analysis Process (EIAP). 1 July.

Defense Force Australia – United States Pacific Command. 2005. *United States Joint Statement of Environmental and Heritage Principles for Combined Activities, signed 18 November.*
Department of Defense (DoD). 1979. Department of Defense Directive (DoDD) 6050.7, *Environmental Effects Abroad of Major Department of Defense Actions*. 31 March.

DoD. 2010. *Quadrennial Defense Review (QDR) Report.* February.

DoD. 2012. *Sustaining US Global Leadership: Priorities for 21st Century Defense*. January.

Department of Natural Resources, Environment, the Arts and Sport, Northern Territory. 2011. *Guide to Environment Protection Approvals and Licenses*, Under the Waste Management and Pollution Control Action. September 2011. Available at: http://www.nretas.nt.gov.au/environment-protection/licences.

EcoLogical. 2012. *Targeted Threatened Species Surveys and Vegetation Mapping RAAF Darwin, Defence Establishment Berrimah and Shoal Bay Receiving Station Final Report*. August.

Environmental Resources Management. 2005. *RAAF Base Darwin Heritage Management Plan*. February.

Federal Register. 1979. *Executive Order 12114, Environmental Effects Abroad of Major Federal Actions*. 4 January.

Federal Register. 1996. *Endangered and Threatened Wildlife and Plants; Reclassification of Saltwater Crocodile Population in Australia From Endangered to Threatened With Special Rule for the Saltwater and Nile Crocodile*. 24 June.

GHD. n.d. *RAAF Base Tindal Facilities Master Plan, Regional Consideration and Existing Infrastructure*.

Gilligan, Leigh. 2012. Personal communication with Michelle Rau. *Asbestos Advice*. 13 November.

Kinhill Engineers. 1987. *Department of Defense RAAF Base Tindal Environmental Management Plan, Bird Strike Mitigation Plan*. October.

Marine Corp Times. 2012. *Corps' new Australia Tours Start in April.* 19 March. Available at: http://www.marinecorpstimes.com/news/2012/03/marine-corps-new-australia-tours-start-april-031912/.

National Greenhouse Energy Reporting (NGER). 2012a. National Greenhouse and Energy Reporting (NGER). Australian Government, Department of Climate Change and Energy Efficiency. *Initiatives.* Updated 12 July 2012. http://www.climatechange.gov.au/government/initiatives/national-greenhouse-energy-reporting.aspx. Accessed 14 November 2012.

NGER. 2012b. National Greenhouse and Energy Reporting. Australian Government, Clean Energy Regulator. *Reporting Obligations*. Updated 23 August 2012. https://www.cleanenergyregulator.gov.au/National-Greenhouse-and-Energy-Reporting/NGER-reporters/Reporting-obligations/Pages/default.aspx. Accessed 14 November 2012.

NGER. 2012c. National Greenhouse and Energy Reporting. *Greenhouse and Energy Information 2010 – 2011.* Australian Government, Clean Energy Regulator, Updated January 7, 2012. http://www.cleanenergyregulator.gov.au/National-Greenhouse-and-Energy-Reporting/Publication-of-NGER-data/greenhouse-and-energy-information/Greenhouse-and-Energy-information-2010-2011/Pages/default.aspx#3. Accessed 14 November 2012.

Northern Territory Department of Health. 2011. *Personal Protection from Mosquitoes & Biting Midges in the NT.* 25 October.

Northern Territory Department of Health. 2012. *Salt Marsh Mosquito Pest Calendar for the Coastal Top End NT 2013*.

Northern Territory Natural Resource Management (Northern Territory). 2011. *Northern Territory Integrated Natural Resource Management Plan 2010-2015*. Territory NRM, Darwin.

Northern Territory. 2010. *Northern Territory Air Monitoring Report 2010*. Greening the Territory. https://www.greeningnt.nt.gov.au>. Accessed 6 November 2012.

National Pollution Inventory (NPI). 2012a. Australian Government, Department of Sustainability, Environment, Water, Population and Communities. National Pollution Inventory. http://www.npi.gov.au/npi/index.html. Accessed 15 November 2012.

NPI. 2012b. Australian Government, Department of Sustainability, Environment, Water, Population and Communities. 2010 – 2011 Northern Territory Data. National Pollution Inventory. http://www.npi.gov.au/npidata/action/load/map-result/criteria/state/NT/year/2011/destination/ALL/source-type/INDUSTRY/subthreshold-data/Yes/substance-name/All. Accessed 14 November 2012.

Pacific Air Forces (PACAF). 2013. *Draft Site Survey Report, RAAF Base Tindal, Australia*. January.

Royal Australian Air Force (RAAF). 1983. *RAAF Base Tindal Draft Environmental Impact Statement*. November.

RAAF. 1997. *Bradshaw Field Training Area, Volume 1- Draft Environmental Impact Statement and Environmental Management Plan.* November.

RAAF. 1999. *RAAF Base Darwin Weed Management Program 1999-2000 Final Report.*

RAAF. 2000. *Initial Environmental Review (IER) for RAAF Base Darwin*. 7 September.

RAAF. 2001. *Environment and Heritage Strategy (EHS) Report*. 22 May.

Sinclair Knight Merz (SKM). 2000. *Phase 1: Initial Environmental Review (IER) for RAAF Base Tindal*. 17 August.

SKM. 2001. *Phase 3: Environmental Management Plan (EMP) for RAAF Base Tindal*. 1 July.

SKM. 2007. *RAAF Tindal Sinkholes*. 29 January.

The White House (White House). 2011. *Remarks by President Obama and Prime Minister Gillard of Australia in Joint Press Conference.* Available at: www.whitehouse.gov. 16 November.

Wildman Land Management. 2005. *RAAF Base Darwin, Fire Management Program Implementation Report - FY 04/05.* 29 June.

United States Air Force (USAF). 1999a. *Air Force Joint Manual (AFJMAN) 23-209, Storage and Handling of Hazardous Materials.*

USAF. 1999b. *Air Force Handbook (AFH) 32-7084, AICUZ Program Mangers Guide*. 1 March.

USAF. 2005. *Air Force Instruction (AFI) 32-1063, Air Installation Compatible Use Zone Program*. 13 September.

United States Fish and Wildlife Service. 2013. *Species Report, Environmental Conservation Online System, Foreign Species*. Available at: http://ecos.fws.gov/tess_public/pub/SpeciesReport.do?lead=10&listingType=L. Updated 30 January.

United States Government – Government of Australia. 1951. *Mutual Defense Assistance Agreement signed February 1 and 20*. 2 U.S.T 644.

United States Government – Government of Australia. 1963. *Agreement on Status of Forces of United States Forces in Australia, signed May 9*. 14 U.S.T. 506.

URS. 2002. *RAAF Base Darwin Surface Water Quality Monitoring Program*, 2001/02. 3 July.

Woods Bagot. 2009. *RAAF Base Darwin Master Plan Report*. 22 May.

Appendix A
Air Emission Calculations

USAF Darwin

Training Frequency (day/yr):	30
JP8 fuel used density (lb/gal)[1]:	6.67

Aircraft Type	Engine Type [2]	Fuel (gal) / day	Personnel	Emissions (ton/day) NOx	CO	VOC	PM10	PM2.5	Emissions (ton/year) NOx	CO	VOC	PM10	PM2.5	CO_2 EF (lb/gal) [4]	CO_2 Emissions (Metric Tonnes/year)
Bomber (B-52)	TF33-P-3/103	32000	75	0.78	0.42	0.13	0.05	0.04	23.31	12.48	3.79	1.45	1.31	20.88	9,091
Tanker (KC-135)	F108-CF-100	30000	60	0.96	0.44	0.00	0.01	0.01	28.77	13.33	0.11	0.35	0.32	20.88	8,522
Fighter (assume F-22)	F119-PW-100	27000	145	0.82	0.53	0.03	0.16	0.14	24.57	16.00	0.84	4.82	4.34	20.88	7,670
								Aircraft Total:	76.65	41.81	4.74	6.62	5.97		25,283

Engine	Power Setting	Duration in power setting (min) [3]	% of time	Emission Factors (lb/1000 lb fuel burned) [4] NOx	CO	VOC	PM10	PM2.5	Fuel (gal/day)	Emissions (lb/day) NOx	CO	VOC	PM10	PM2.5
		Not included for Training												
TF33-P-3/103 (Bomber)	Idle	(32.8+14.9)	0%	1.39	94.87	86.69	1.9	1.71	0	0	0	0	0	0
	Approach	5.2	62%	6.36	5.23	1.31	0.35	0.32	19810	840	691	173	46	42
	Intermediate = climbout	2.5	30%	7.86	1.86	0.98	0.68	0.61	9524	499	118	62	43	39
	Military = takeoff	0.7	8%	12.05	1.29	0.98	0.39	0.35	2667	214	23	17	7	6
		Not included for Training												
F108-CF-100 (Tanker)	Idle	(32.8+14.9)	0%	3.93	27.13	0.88	0.12	0.11	0	0	0	0	0	0
	Approach	5.2	62%	6.94	6.38	0.04	0.11	0.1	18571	860	790	5	14	12
	Intermediate = climbout	2.5	30%	13.5	1.34	0.03	0.13	0.12	8929	804	80	2	8	7
	Military = takeoff	0.7	8%	15.25	1.12	0.03	0.13	0.12	2500	254	19	1	2	2
		Not included for Training												
F119-PW-100 (F-22)	Idle	(9.2+6.7)	0%	3	48.2	6.48	2.49	2.24	0	0	0	0	0	0
	Approach	4	68%	6.6	7.9	0.29	2	1.8	18305	806	965	35	244	220
	Intermediate = climbout	1.4	24%	12.4	2.1	0.48	1.41	1.27	6407	530	90	21	60	54
	Military = takeoff	0.5	8%	19.8	0.8	0	1.12	1.01	2288	302	12	0	17	15
	AB	NA	0%	7.4	16.1	0.19	NA	NA	0	0	0	0	0	0

Calculated Values
Site Data or Data from Reference Material
Assumed Data

1 Conversion Values Table 2-9 AFCEE, 2009.
2 The APU emissions are not included in this estimate because their emission factors are lower than the main engine emission factor. Engine types were taken from Table 1-2 (AFCEE, 2009).
No emission factors were available for UAVs; therefore, it was assumed that the F-22 would be similar in nature to provide an estimate of the total emissions.
3. Assumed USAF-general for duration in power setting for F-22 and USAF B-52 and KC-135 for Bomber and Tanker, respectively (Table 1-8; AFCEE, 2009).
4. Emission factors are taken from Table 1-4 and 1-9 (AFCEE, 2009).

Notes:
TGO and LFB emissions are calculated in essentially the same manner as LTO emissions. Due to the nature of the operational and training requirements for the cycle, however, the taxi/idle-in and taxi/idleout modes are not included.

Reference: Air Emissions Factor Guide to Air Force Mobile Sources, December 2009.

USAF Tindal

Training Frequency (day/yr):	30
JP8 fuel used density (lb/gal)[1]:	6.67

Aircraft Type	Engine Type [2]	Fuel (gal) / day	Personnel	Emissions (ton/day) NOx	CO	VOC	PM10	PM2.5	Emissions (ton/year) NOx	CO	VOC	PM10	PM2.5	CO_2 EF (lb/gal) [4]	CO_2 Emissions (Metric Tonnes/year)
Bomber (B-52)	TF33-P-3/103	32000	75	0.78	0.42	0.13	0.05	0.04	23	12	4	1	1	20.88	9,091
Tanker (KC-135)	F108-CF-100	30000	60	0.96	0.44	0.00	0.01	0.01	29	13	0.1	0.4	0.3	20.88	8,522
Fighter (assume F-22)	F119-PW-100	27000	145	0.82	0.53	0.03	0.16	0.14	25	16	1	5	4	20.88	7,670
UAV	NA	940	60	0.03	0.02	0.00	0.01	0.01	1	1	0.03	0.2	0.2	20.88	267
								Aircraft Total:	**78**	**42**	**5**	**7**	**6**		**25,550**

Engine	Power Setting	Duration in power setting (min) [3]	% of time	Emission Factors (lb/1000 lb fuel burned) [4] NOx	CO	VOC	PM10	PM2.5	Fuel (gal/day)	Emissions (lb/day) NOx	CO	VOC	PM10	PM2.5
		Not included for Training												
TF33-P-3/103 (Bomber)	Idle	(32.8+14.9)	0%	1.39	94.87	86.69	1.9	1.71	0	0	0	0	0	0
	Approach	5.2	62%	6.36	5.23	1.31	0.35	0.32	19810	840	691	173	46	42
	Intermediate = climbout	2.5	30%	7.86	1.86	0.98	0.68	0.61	9524	499	118	62	43	39
	Military = takeoff	0.7	8%	12.05	1.29	0.98	0.39	0.35	2667	214	23	17	7	6
		Not included for Training												
F108-CF-100 (Tanker)	Idle	(32.8+14.9)	0%	3.93	27.13	0.88	0.12	0.11	0	0	0	0	0	0
	Approach	5.2	62%	6.94	6.38	0.04	0.11	0.1	18571	860	790	5	14	12
	Intermediate = climbout	2.5	30%	13.5	1.34	0.03	0.13	0.12	8929	804	80	2	8	7
	Military = takeoff	0.7	8%	15.25	1.12	0.03	0.13	0.12	2500	254	19	1	2	2
		Not included for Training												
F119-PW-100 (F-22)	Idle	(9.2+6.7)	0%	3	48.2	6.48	2.49	2.24	0	0	0	0	0	0
	Approach	4	68%	6.6	7.9	0.29	2	1.8	18305	806	965	35	244	220
	Intermediate = climbout	1.4	24%	12.4	2.1	0.48	1.41	1.27	6407	530	90	21	60	54
	Military = takeoff	0.5	8%	19.8	0.8	0	1.12	1.01	2288	302	12	0	17	15
	AB	NA	0%	7.4	16.1	0.19	NA	NA	0	0	0	0	0	0
		Not included for Training												
UAV	Idle	(9.2+6.7)	0%	3	48.2	6.48	2.49	2.24	0	0	0	0	0	0
	Approach	4	68%	6.6	7.9	0.29	2	1.8	637	28	34	1	9	8
	Intermediate = climbout	1.4	24%	12.4	2.1	0.48	1.41	1.27	223	18	3	1	2	2
	Military = takeoff	0.5	8%	19.8	0.8	0	1.12	1.01	80	11	0	0	1	1
	AB	NA	0%	7.4	16.1	0.19	NA	NA	0	0	0	0	0	0

Calculated Values
Site Data or Data from Reference Material
Assumed Data

1 Converstion Values Table 2-9 AFCEE, 2009
2 The APU emissions are not included in this estimate because their emission factors are lower than the main engine emission factor. Engine types were taken from Table 1-2 (AFCEE, 2009).
No emission factors were available for UAVs; therefore, it was assumed that the F-22 would be similar in nature to provide an estimate of the total emissions.
3 Assumed USAF-general for duration in power setting for F-22 and USAF B-52 and KC-135 for Bomber and Tanker, respectively (Table 1-8; AFCEE, 2009).
4 Emission factors are taken from Table 1-4 and 1-9 (AFCEE, 2009).

TGO and LFB emissions are calculated in essentially the same manner as LTO emissions. Due to the nature of the operational and training requirements for the cycle, however, the taxi/idle-in and taxi/idleout modes are not
Thus a shallow mixing zone height will result in a shorter TIM (and fewer emissions), and a high mixing zone height will result in a longer TIM (and more emissions). While emissions occurring anywhere within this zone will

Reference: Air Emissions Factor Guide to Air Force Mobile Sources, December 2009

Appendix B
Aircraft Noise Study

Do to size limitations the Aircraft Noise Study can be found on the project SharePoint site.

The study will be included in all hardcopies of the document.

Aircraft Noise Study for PACAF Exercises at RAAF Bases Darwin and Tindal, Northern Territory, Australia

Contract Number: HC1047-05-D-4005

Task Order: TAT 203

20 February 2013

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1.0 Introduction

The United States (US) Pacific Air Forces (PACAF) is proposing to conduct two 15-day exercises per year at Royal Australian Air Force (RAAF) Bases Darwin and Tindal. RAAF Base Darwin is co-located with Darwin International Airport.

The US Department of Defense (DoD) requires analysis of potential noise impacts and encroachment per DoDD 3200.15. Guidance for noise analysis is provided by the Defense Noise Working Group (DNWG). US Air Force (USAF) noise policy is specified in AFI 32-7063 and AFH 32-7084. The Australian Defence Support Group (DSG) is responsible for assessing environmental impacts on Australian military installations. DSG provides guidance for Australian noise analysis. The noise metrics used by DoD and DSG are different; however, metrics used by DSG are recommended as supplemental metrics by DNWG. Therefore noise analysis in this Technical Note (TN) holds utility for PACAF and DSG decision-makers.

While the proposed USAF exercises would be relatively small, there are sensitivities of how noise is assessed and presented to the Australian public. There is growing concern among the local community regarding military fighter aircraft noise at Darwin and Tindal, among other locations. A community action group in Darwin called BaseWatch has become increasingly active over the past 2-3 years, according to DSG Northern Territory (NT) environmental managers.

This Technical Note (TN) describes the aircraft noise exposure for the proposed PACAF exercises. The exercise is notional for current planning purposes. The categories of aircraft involved in the exercises would be fighters, tankers, bombers, and reconnaissance. The reconnaissance aircraft would only utilize RAAF Base Tindal. With two 15-day exercises per year, either base would endure 30 days of proposed PACAF activity per year.

Section 2 describes the methodology used to perform the noise analysis. Sections 3 and 4 describe the modeled operations and noise exposure at RAAF Bases Darwin and Tindal, respectively.

2.0 Methodology

2.1 Noise Model, AAD and ABD Metrics and Significance Thresholds

This noise analysis was conducted according to established DoD guidelines and best practices and leveraged the DoD NOISEMAP suite of computer-based modeling tools (Czech and Plotkin 1998; Page et al, 2012; Wasmer and Maunsell 2006a; Wasmer and Maunsell 2006b). The suite primarily includes BaseOps, NMAP, the Advanced Acoustic Model (AAM) and NMPlot. NMAP and AAM are semi-empirical models starting their calculations from databases of measured noise levels of dedicated flyovers and run-ups. NMAP's acoustic database is called NOISEFILE and AAM's acoustic database is comprised of Network Common Data Form (NetCDF) files. The versions of NMAP and AAM used for this TN were 7.2 and 1.4.8, respectively.

Four categories of aircraft are modeled -- Fighters (e.g., F-15 Eagle, F-22 Raptor), Tankers (e.g., KC-10 Extender, KC-135 Stratotanker), Bombers (e.g., B-1 Lancer, B-52 Stratofortress) and Reconnaissance (RQ-4 Global Hawk). The loudest aircraft type of each category (on a single-event basis) was modeled, i.e., F-22 for Fighters, KC-10A for Tankers and B-1 for Bombers. The Citation X (CITX) was chosen as a conservative surrogate for RQ-4 flight operations because there is no acoustic reference data for the

RQ-4 in the models. The T-45 was chosen as the surrogate for RQ-4 run-up operations because there is no acoustic reference data for the RQ-4 (or for the CITX) in the models.

NMAP's database included the aircraft of interest but for AAM, the NetCDF files needed to be developed. NetCDF files basically describe spheres of one-third octave band sound pressure levels (called "noise spheres") for each aircraft type. A noise sphere consists of spectral noise levels at a specified angular resolution and radius.

The spheres utilized for this project are summarized in Table 2-1. Each aircraft has a set of spheres for different power condition or aircraft configuration (i.e. in flight, static, gear down, afterburner, etc.). The data values of the noise sphere come from either measured or legacy data sources. Legacy data comes via INM's or NMAP's database and is in the form of SEL as a function of power setting and nominal spectral levels. Different aircraft types have different directional noise shapes, so these spectral levels are adjusted to account for the directionality of a certain aircraft type. For example, fighter jets have a different "noise footprint" on the ground than tankers. Other considerations, such as Doppler shifts, are also taken into account in the spectral directionality of the sphere data.

Table 2-1. Sphere Summary

Vehicle Category	Aircraft Type	Data Source	Longitudinal Directivity	Lateral Adjustments
Fighters	F-22	Measured Data	Measured	Side-by-side + Rectangular Jet
Tankers	KC-10A	INM	INM Cardioid	None
Bombers	B-1	Noisefile	Nominal Fighter Shape	Side-by-side Jet
Reconnaissance	Citation X / T-45 (1)	Noisefile /INM	INM Cardioid	INM Fuselage-Mounted

Notes: (1) T-45 Used for Static Data, Citation X used for Flight Data

The US and Australia rely on cumulative metrics for evaluation of noise exposure. In the US, the DOD via DOD Instruction (DODI) 4165.57 requires cumulative noise exposure be described and presented in terms of Day-Night Average Sound Level (DNL). DNL is a composite noise metric accounting for the sound energy of all noise events in a 24-hour period. Flight and run-up events are measured in terms of their (integrated, normalized to one second) Sound Exposure Level (SEL) and (instantaneous) Maximum Sound Level (L_{max}), respectively. SEL and L_{max} are expressed in A-weighted decibels (dB or dBA). In order to account for increased human sensitivity to noise at night, a 10 dB penalty is applied to nighttime events (10:00 p.m. to 7:00 a.m. time period).

In Australia, the DSG requires cumulative noise exposure be described in terms of the Australian Noise Exposure Forecast (ANEF). Like DNL, ANEF is a composite noise metric accounting for the sound energy of all noise events in a 24-hour period, but ANEF is based on Effective Perceived Noise Level (EPNL) for flight events and Tone-Corrected Perceived Noise Level (PNLT) for run-up events. EPNL and PNLT are expressed in decibels of perceived noise (PNdB). The other differences between DNL and ANEF are ANEF's nighttime period is from 7:00 p.m. to 7:00 a.m. and its nighttime penalty is 6 dB.

NMAP and AAM can directly compute US NEF but not ANEF. US NEF has the following features:

a) Daytime period of 7:00 a.m. to 10:00 p.m.

b) Nighttime period of 10:00 p.m. to 7:00 a.m.

c) Nighttime weighting of 12.2 PNdB (multiplier of 16.67).

To compute ANEF, evening (7:00 p.m. to 10:00 p.m.) operations were assigned to the nighttime period and the resultant ANEF nighttime (7:00 p.m. to 7:00 a.m.) operations were divided by 4.1675 (i.e. 16.67/4) prior to entry to NMAP or AAM. The FAA's Integrated Noise Model (INM) can compute ANEF directly (see below for how INM was applied and its citation).

Due to their 24-hour nature, DNL and ANEF require flight and run-up operations to be described on a daily basis. Per DODI 4165.57, cumulative noise exposure can be presented in terms of annual average daily (AAD) operations and/or average busy day (ABD) operations. AAD is simply the number of annual operations divided by 365. ABD is defined as the number of operations occurring during the exercises divided by the number of exercise days. For this TN, as there are two identical exercises, each lasting 15 days, the total number of annual exercise operations is divided by 30.

Table 2-1 lists the noise metric computed for this TN, contours shown and thresholds chosen. For DNL and ANEF, contour levels of 65-85 dB DNL and 20-40 PNdB, in 5 dB increments are presented. This TN also includes presentation of DNWG supplemental metrics of Number of Events (at or) Above a Selected Threshold (NA) and Time (at or) Above a Selected Threshold (TA) (DNWG 2009). For NA and TA, thresholds of 70, 85 and 100 dBA L_{max} were selected. As companion to the NA and TA maps, the L_{max} was also computed with showing contours of 70, 85 and 100 dBA. All of the metrics, except ANEF, were computed for the ABD (PACAF exercises only).

The official 2030 ANEF at Darwin is based on 173 flying days during the wet season (low-tempo) and includes civilian and military activity. It was previously modeled using standard weather values of 59°F and 70% RH (DSG 2010). This is considered baseline at Darwin. PACAF exercise activity was scaled to the 173 flying days with the same weather condition to make direct comparison of ANEF for contribution of proposed action.

ANEF contours are formally adopted and designate official forecast of aircraft operations noise. Scenarios other than the official ANEF are considered by DSG to be a concept and denoted as Australian Noise Exposure Concept (ANEC). Inclusion of the PACAF exercise in the 2030 ANEF is considered a concept and will be referred to as the Proposed Action ANEC or ANEC, for the purposes of this report.

As depicted in Table 2-2, NMAP was used to compute DNL and ANEC for PACAF exercise aircraft operations. The FAA's Integrated Noise Model (INM), Version 6.2a (FAA 2002), was used to compute ANEF for non-PACAF aircraft at Darwin. AAM was used to compute NA, TA and L_{max}. NMAP 7.2 is not able to compute NA, TA or L_{max}. INM 6.2a was used on previous DSG analyses (DSG 2010).

Table 2-2. Metrics Computed and Types of Daily Events

Metric	Contours or Thresholds Shown/ Computed	Darwin	Tindal
DNL (dBA)	65, 70, 75, 80, 85	Baseline = ANEC1+ANEC2+ANEC3; Proposed = Baseline+PACAF aircraft; AAD only	AAD, ABD (PACAF exercises only)
ANEF (PNdB)	20, 25, 30, 35, 40	2030 ANEF = ANEC2 for non-PACAF aircraft; Proposed = 2030 ANEF + PACAF aircraft; averaged over 173 days	AAD only (PACAF exercises only)
NAxxxALM	70, 85, 100 dBA; 1, 15, 30 events per 24 hours	ABD only (PACAF exercises only)	
TAxxxALM	70, 85, 100 dBA; 1, 5, 10, 15 minutes per 24 hours		
Lmax (dBA)	70, 85, 100		

= INM for non-PACAF exercise aircraft + NMAP for PACAF exercise aircraft
= NMAP
= AAM

Noise-sensitive land uses, such as housing, schools, places of worship, and medical facilities are considered as being compatible in areas where the AAD DNL is less than 65 dB. Noise sensitive land uses are discouraged in areas where the AAD DNL is between 65 and 69 dB, and strongly discouraged where the AAD DNL is between 70 and 74 dB. At higher levels, i.e. greater than 75 dB, land use and related structures are not compatible and should be prohibited.

NMAP, AAM and INM can incorporate the number of day, evening, and night operations, flight paths, and profiles of the aircraft to calculate the noise metrics at many points five feet above the surface around the two bases. This process results in a "grid" file containing noise levels at different points of a user specified rectangular area. For NMAP and AAM, the spacing of the grid points for this study was 500 feet. INM computes an irregular grid with 'refinement' and 'tolerance' parameters. Consistent with previous DSG analyses of Darwin, a refinement and tolerance of 10 and 0.1 dB, respectively, were used.

The programs can also compute all metrics for specific Points of Interest (POI), e.g., noise-sensitive receptors, and determine the primary contributors to the overall DNL at each point. For this study, five POIs were modeled in the vicinity of Tindal, and 19 POIs were modeled in the vicinity of Darwin. See Sections 3 and 4 for further discussion of the POIs and the resulting noise levels at each POI.

In calculating time-average sound levels for airfields, the reliability of the results varies at lower levels (below 45 dB DNL/L_{eq}). This arises from the increasing variability of individual aircraft sound levels at the longer distances due to atmospheric effects on sound propagation and to the presence of other sources of noise. Also, when flight activity is infrequent, the time-averaged sound levels are generated by only a few individual aircraft noise events, which may not be statistically representative of the given aircraft modeled. Time-averaged outdoor sound levels less than 45 dB DNL are well below any

currently accepted guidelines for aircraft noise compatibility. Most of the guidelines for the acceptability of aircraft noise are on the order of 65 dB and higher. Therefore, DNL less than 45 dB are presented herein as "<45 dB". Furthermore, ANEF less than 0 PNdB are presented as "<0 PNdB".

The models listed herein are the most accurate and useful for comparing "before-and-after" noise levels that would result from alternative scenarios when calculations are made in a consistent manner. The programs allow noise exposure prediction of such proposed actions without actual implementation and/or noise monitoring of those actions.

2.2 Geospatial Data

The NOISEMAP suite of programs includes the ability to account for atmospheric sound propagation effects over varying terrain, including hills and mountainous regions, as well as regions of varying ground acoustical impedance—for example, water around coastal regions. This feature is used in computing the NMAP- and AAM-generated noise levels presented in this analysis. By including terrain in the propagation calculations, the shielding effect of landforms can be included in the analysis.

Elevation grid files with a grid point spacing of 500 feet were created from the 1 arc-second Shuttle Radar Topographic Mission (SRTM) derived smoothed Digital Elevation Model (DEM-S) Version 1.0 data (Geoscience Australia 2012). This data represents ground surface topography, excluding vegetation features, and has been smoothed to reduce anomalies and improve the representation of surface shape. The data provides substantial improvements in the quality and consistency of the data relative to the original SRTM data, but is not free from artifacts. SRTM data is 'first return' data, i.e., the elevations measured are that of the first reflective surface that the radar signal encounters. While vegetation was removed from this final dataset, man-made structures such as urban areas and power line towers were not. Although INM cannot account for the shielding effect of landforms, it can account for the elevation of the terrain.

Acoustical impedance describes how sound is reflected or absorbed by the surface. Sound tends to travel farther over hard surfaces, such as pavement or water, than it does over soft surfaces, such as plowed earth or vegetation. This feature was used for computing the noise levels presented in this analysis. The Katherine River northwest of RAAF Tindal, and the Beagle Gulf and Port Darwin surrounding RAAF Darwin were modeled as hard surfaces with acoustical impedance (flow resistivity) of 1,000,000 kPa-s/m^2. This is consistent with standard practice, and all non-water surfaces in the study area were modeled with "soft" acoustical impedance (flow resistivity) of 200 kPa-s/m^2.

INM's algorithms approximate "soft" ground impedance for all surfaces.

3.0 RAAF Darwin

RAAF Darwin is co-located with Darwin International Airport (DRW) in Darwin, Northern Territory (NT). With a population of approximately 212,000, the city of Darwin holds approximately 90 percent of the population of the NT (233,000 people). DRW is one of a small handful of Australian airports which do not operate with a nighttime curfew. The preponderance of activity is civilian passenger jets with large percentage of operations occurring between 11:00 p.m. and 3:00 a.m. These are typically in-bound international flights with connections to Sydney, Brisbane or Melbourne. The midnight departures from DRW are scheduled to arrive between 6:00 a.m. and 7:00 a.m. at other major Australian airports in order to match their morning international connections (Robinson 2012a).

No permanent military aircraft are based at RAAF Darwin. However, RAAF Darwin is used for several Australian and multi-nation military exercises. Examples of on-going joint exercises are Pitch Black and

Talisman-Sabre which occur biennially on alternating years. Such military exercises typically occur during the dry season (May-Oct) (Robinson 2012a).

The following three subsections detail the modeling data and the resultant noise exposure in the vicinity of RAAF Darwin.

3.1 Modeling Data

As provided by PACAF (Robinson 2012b), Table 3-1 details the proposed flight operations at RAAF Darwin which would total nearly 1,000 annual PACAF military operations. There would be two exercises per year, and each exercise would last 15 days resulting in a total of 30 operating days per year for PACAF aircraft at RAAF Darwin. The temporal utilization of each aircraft category was from interviews with RAAF operators (Robinson 2012a). No departure flight operations occurring during the DNL nighttime period (10:00 p.m. to 7:00 a.m.) are anticipated. Two percent of Fighter arrivals would be during the DNL nighttime period whereas five percent of Tanker and Bomber arrivals would be during the DNL nighttime period. No pattern operations are forecast.

The Fighters would perform only pitch-out arrivals with no straight-in arrivals while the Tankers and Bombers would perform only straight-in arrivals.

The runway and flight track utilization percentages are listed in Table 3-2. For each operation type and all three modeled aircraft types, Runways 29 and 11 would be used for 65 and 35 percent of flight operations, respectively. Runway utilization was derived from previous Darwin modeling (DSG 2010).

Table 3-2 also lists the flight track utilization. As there would only be one flight track per combination of operation type and runway, this portion of Table 3-2 is blank. The modeled flight tracks for the PACAF aircraft at DRW are presented in Figure 3-1. The modeled arrival and departure KC-10 and B-1 flight tracks are straight-out departures and straight-in arrivals. The modeled F-22 departures are straight-out. The modeled F-22 arrivals are pitch-out arrivals derived from a Wyle F-22 pilot (Batterton 2013a) which break at the beginning of the runway, have an abeam distance of 1 nm, a 1 nm downwind segment, and a 1 nm final leg.

With regard to flight profile utilization in Table 3-2, the Bomber category was modeled with the B-1 aircraft type. As such, it was assumed all B-1 departures would employ afterburner takeoffs. Conversely, the Fighter category is assumed to never utilize afterburners on takeoff. Representative profiles for each modeled aircraft type are presented in Appendix A. F-22 profiles were reviewed and modified via flight simulator by a Wyle F-22 pilot (Batterton 2013b).

As NOISEMAP requires events to be input on an average daily basis, the annual flight operations of Table 3-1 were divided by the number of flying days shown in Table 3-1 for the ABD case (and the L_{max}, TA and NA metrics) or by 365 for the AAD DNL case.

Run-ups are events that take place with the aircraft parked on the ground and the engine running to conduct various pre-flight checks, tests or repairs. Sometimes the engine may be removed from the aircraft, but for all run-ups at Darwin, the engines would remain in-frame.

At RAAF Darwin, all three modeled aircraft perform various types of run-ups. Table 3-3 presents the annual run-up events for PACAF exercises at RAAF Darwin. Figure 3-2 presents the modeled run-up pad locations listed in Table 3-3. All three modeled aircraft are expected to perform 5-minute pre-flight checks at the hammerheads of the runways. Fighters, Tankers and Bombers would perform "warm-up" run-ups prior to each departure at their respective ramp location. The F-22, KC-10 and B-1 warm-ups would be 15 minutes, 5 minutes and 30 minutes, respectively. The B-1 would also conduct 5-minute "cool down" run-ups after each arrival. All of these run-ups would be at relatively low power settings.

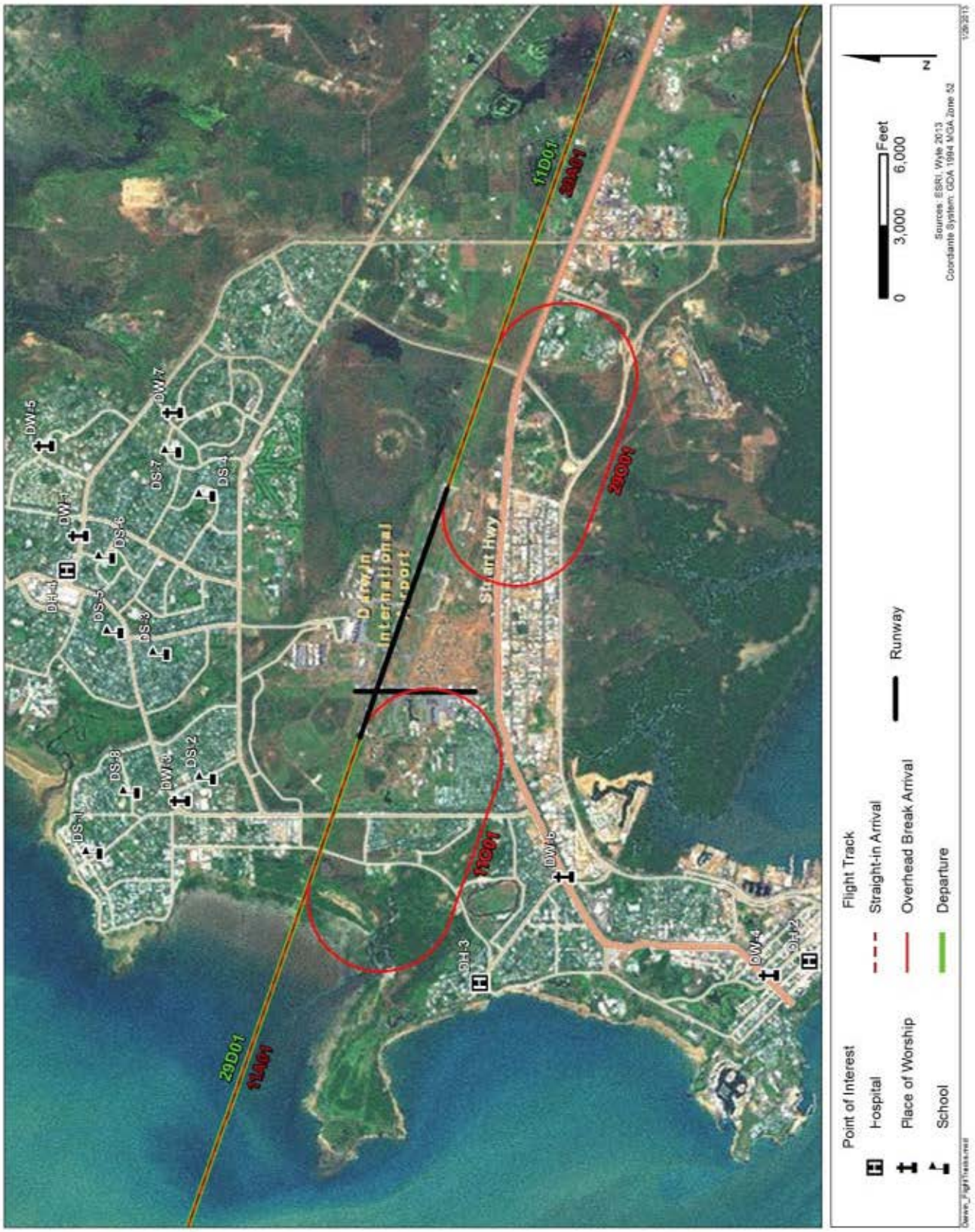

Figure 3-1. Modeled Flight Tracks at RAAF Darwin

Figure 3-2. Modeled PACAF Aircraft Run-up Locations at RAAF Darwin

Table 3-1. Annual Flight Operations for PACAF Exercises at RAAF Darwin (2 x 15 day Exercises per Year)

Group	Modeled Aircraft Type	Number of Flying Days (1)	Temporal Departure Utilization			Temporal Arrival Utilization		
			Day (0700-1900)	Evening (1900-2200)	Night (2200-0700)	Day (0700-1900)	Evening (1900-2200)	Night (2200-0700)
Fighter (F-15E, F-22)	F-22	30	95%	5%	0%	90%	8%	2%
Tanker (KC-10)	KC-10A	30	95%	5%	0%	55%	40%	5%
Bomber (B-1, B-52)	B-1	30	95%	5%	0%	55%	40%	5%
Reconnaissance	n/a	n/a	95%	5%	0%	90%	8%	2%

Group	Modeled Aircraft Type	Number of Flying Days (1)	Departure				Straight-in Arrival				Pitch-Out Arrival				Total			
			Day (0700-1900)	Evening (1900-2200)	Night (2200-0700)	Total	Day (0700-1900)	Evening (1900-2200)	Night (2200-0700)	Total	Day (0700-1900)	Evening (1900-2200)	Night (2200-0700)	Total	Day (0700-1900)	Evening (1900-2200)	Night (2200-0700)	Total
Fighter (F-15E, F-22)	F-22	30	342	18	-	360	-	-	-	-	324	29	7	360	666	47	7	720
Tanker (KC-10)	KC-10A	30	57	3	-	60	33	24	3	60	-	-	-	-	90	27	3	120
Bomber (B-1, B-52)	B-1	30	57	3	3	63	33	24	3	60	-	-	-	-	90	27	6	123
Reconnaissance	n/a	n/a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL			**456**	**24**	**3**	**483**	**66**	**48**	**6**	**120**	**324**	**29**	**7**	**360**	**846**	**101**	**16**	**963**

Note:
1) 2 exercises per year, 15 days per exercise

Table 3-2. Runway and Flight Track Utilization of Modeled PACAF Aircraft at RAAF Darwin

Modeled Aircraft Type	Operation Type	Runway				Flight Track					Profile				
			Percentages (1)					Percentages (2) (if not 100%)					Percentages (3) (if not 100%)		
		ID	Day (0700-1900)	Evening (1900-2200)	Night (2200-0700)	ID	Description	Day (0700-1900)	Evening (1900-2200)	Night (2200-0700)	ID	Description	Day (0700-1900)	Evening (1900-2200)	Night (2200-0700)
F-22	Departure	11	35%	35%	35%	11D01	Straight Out Departure				101	Afterburner	0%	0%	0%
											100	Mil			
		29	65%	65%	65%	29D01	Straight Out Departure				103	Afterburner	0%	0%	0%
											102	Mil			
	Straight-in Arrival	11	35%	35%	35%	11A01	Straight In Arrival								
		29	65%	65%	65%	29A01	Straight In Arrival								
	Pitch-out Arrival	11	35%	35%	35%	11O01	Pitch-out Arrival; Break at beginning of runway; 1 NM Abeam; 1 NM Downwind; 1 NM Final				120	Standard Arrival			
		29	65%	65%	65%	29O01	Pitch-out Arrival; Break at beginning of runway; 1 NM Abeam; 1 NM Downwind; 1 NM Final				121	Standard Arrival			
KC10A	Departure	11	35%	35%	35%	11D01	Straight Out Departure				200	Standard Departure			
		29	65%	65%	65%	29D01	Straight Out Departure				201	Standard Departure			
	Straight-in Arrival	11	35%	35%	35%	11A01	Straight In Arrival				210	Standard Arrival			
		29	65%	65%	65%	29A01	Straight In Arrival				211	Standard Arrival			
B-1	Departure	11	35%	35%	35%	11D01	Straight Out Departure				300	Afterburner			
												Mil	0%	0%	0%
		29	65%	65%	65%	29D01	Straight Out Departure				301	Afterburner			
												Mil	0%	0%	0%
	Straight-in Arrival	11	35%	35%	35%	11A01	Straight In Arrival				310	Standard Arrival			
		29	65%	65%	65%	29A01	Straight In Arrival				311	Standard Arrival			

Note:
1) within runway op type
2) within specific runway
3) within specific flight track

Table 3-3. Annual PACAF Run-up Events at RAAF Darwin (2 x 15 Day Exercises per Year)

Aircraft Type	Engine Type	Run-up Type	In-frame / Out-of-frame	Run-up Pad ID	Magnetic Heading (degrees)	Pad%	Annual Events				Power Setting	Duration (Minutes Per Event)	# of Engines Running (per event)
							Day (0700-1900)	Evening (1900-2200)	Night (2200-0700)	Total			
F-22	F119-PW-100	15 min Warm-up	In-frame	FRA1	20	50%	171	9	-	180	10% ETR	15	2
				FRA2	20	50%	171	9	-	180	10% ETR	15	2
		Hammerhead pre-flight checks	In-frame	HH11	20	35%	120	6	-	126	10% ETR	5	2
				HH29	20	65%	222	12	-	234	10% ETR	5	2
KC-10A	CF6-50C2	5 min Warm-up	In-frame	BRA1	20	50%	29	2	-	30	24% N1	5	3
				BRA2	20	50%	29	2	-	30	24% N1	5	3
		Hammerhead pre-flight checks	In-frame	HH11	20	35%	20	1	-	21	24% N1	5	3
				HH29	20	65%	37	2	-	39	24% N1	5	3
B-1	F101-GE-100	30 min warm-up/ 5 min cool-down	In-frame	BRA1	20	50%	29	2	2	32	80% RPM	30	4
						50%	17	12	2	30	80% RPM	5	4
				BRA2	20	50%	29	2	2	32	80% RPM	30	4
						50%	17	12	2	30	80% RPM	5	4
		Hammerhead pre-flight checks	In-frame	HH11	20	35%	20	1	1	22	80% RPM	5	4
				HH29	20	65%	37	2	2	41	80% RPM	5	4

3.2 Noise Exposure

Figure 3-3 shows the Baseline 65 dB to 85 dB DNL contours in 5 dB increments at Darwin for annual average daily (AAD) operations. Baseline represents all existing and forecasted civilian and military activity as modeled previously in the 2030 ANEC, including low-tempo wet season activity, high-tempo dry season activity and helicopter activity. All operations were averaged over 365 days and modeled for weather conditions specific to season, i.e. wet season corresponds to November-April conditions and dry season corresponds to May-October conditions. Weather data used was the 56-year average for the 3pm temperature and relative humidity obtained from Australian Bureau of Meteorology (ABM 2012a).

USAF policy for significant noise impact is determined on a case-by-case basis due to the wide variety of aircraft, e.g. fighters, heavies, props, etc. and operation types (year-round operations to short-duration exercises) at differing locations (urban to rural). In general, a 2 dB or greater increase within the AAD 65 dB DNL contour is considered significant.

Figure 3-4 shows the resultant 65 dB to 85 dB DNL contours in 5 dB increments for Proposed Action Darwin AAD, i.e. Baseline plus PACAF exercises. Comparison of Proposed Action to Baseline is shown in Figure 3-5. It can be seen that the increase in AAD DNL for the Proposed Action would be minimal for all areas with some increase to the west of Runway 29. No noise sensitive area within the AAD 65 dB DNL contour would experience an increase greater than or equal to 2 dB DNL. Therefore, per USAF policy, there would be no significant impact or potential for harm from the Proposed Action.

Figure 3-6 shows the resultant 65 dB to 85 dB DNL contours in 5 dB increments for Darwin ABD PACAF exercises only, i.e. average noise exposure during the exercise. The 65 dB DNL contour would extend approximately 2.25 miles to the northwest from the shoreline and approximately 3.3 miles from the threshold of the approach end of Runway 29 to the southeast. The halfwidth of the 65 dB DNL contour, i.e., distance perpendicular to Runway 11/29, would be approximately 4800 feet.

Among the PACAF aircraft, DNL exposure would be dominated nearly equally by the Fighter and Bomber flight operations. This is because the modeled B-1 bomber departs using afterburner (AB). Other bomber aircraft would likely generate less exposure than the Fighters because other bomber aircraft (i.e., B-52) do not have AB capability.

Figures 3-7 through 3-13 show the 24-hour L_{max}, NA and TA contours and gradients for Darwin ABD PACAF exercises only, per Table 2-2.

Figure 3-14 shows the resultant 20 dB to 40 dB ANEC contours in 5 dB increments for Darwin ABD (173 days). Figure 3-12 includes non-exercise aircraft. The 20 PNdB ANEC contour would extend approximately 2.4 miles to the northwest from the shoreline and approximately 3.75 miles from the threshold of the approach end of Runway 29 to the southeast. The halfwidth of the 20 PNdB ANEC contour would be approximately 1 mile. ANEC exposure would be dominated by PACAF's Bomber flight operations.

The modeled Points of Interest (POI) selected for RAAF Darwin were depicted in the aforementioned figures but are shown by themselves in their entirety in Figure 3-13. The POIs are located north and southwest of the airfield and consist of 4 hospitals, 8 schools and 7 places of worship. Two of the POIs (DH-1 Royal Darwin Hospital and DW-2 Christ Cathedral Anglican) are too far north and south of the airfield to be included in the extents of Figures 3-3 through 3-12.

Table 3-4 presents the noise metrics computed for ABD operations for each of the 19 POI for RAAF Darwin. No POIs would be exposed to DNL greater than or equal to 65 dB. The POI with the greatest DNL would be DS-2 (Millner Primary School) with a DNL of 63 dB.

Table 3-4 also lists the L_{max}, NA and TA for each of the Darwin POI. L_{max} would range from 77 dB at DW-2 (Christ Cathedral Anglican) to 94 dB at DS-2 (Millner Primary School). Correspondingly, no events or time at or above 100 dB L_{max} would occur at the selected POI. The greatest NA 70 dB L_{max} would be 14 at 9 of the 19 POI (i.e., 6 schools and 3 places of worship). This analysis assume conservative (over-estimate) worst-case scenario with loudest fighters (F-22) and bombers (B-1). If different aircraft were modeled then the exposure would be less. Additionally, the levels presented reflect outdoor noise levels. With open or closed windows, indoor noise levels would be attenuated by approximately 15 or 25 dB, respectively (USEPA 1974). The intuitive conclusion is that noise exposure at the POI during the proposed exercise would be noticeable with single events noise levels increasing above ambient noise levels; however cumulative daily exposure will not be intrusive or significant.

Table 3-5 presents the noise metrics computed for AAD operations for each of the 19 POI for RAAF Darwin. No POI would be exposed to DNL greater than or equal to 65 dB due to PACAF operations.

All POI would be exposed to ANEF less than or equal to 20 PNdB due to PACAF and non-PACAF operations. The POI with the greatest DNL and ANEF would be DS-2 (Millner Primary School) with a DNL of 52 dB and an ANEF of 20 PNdB.

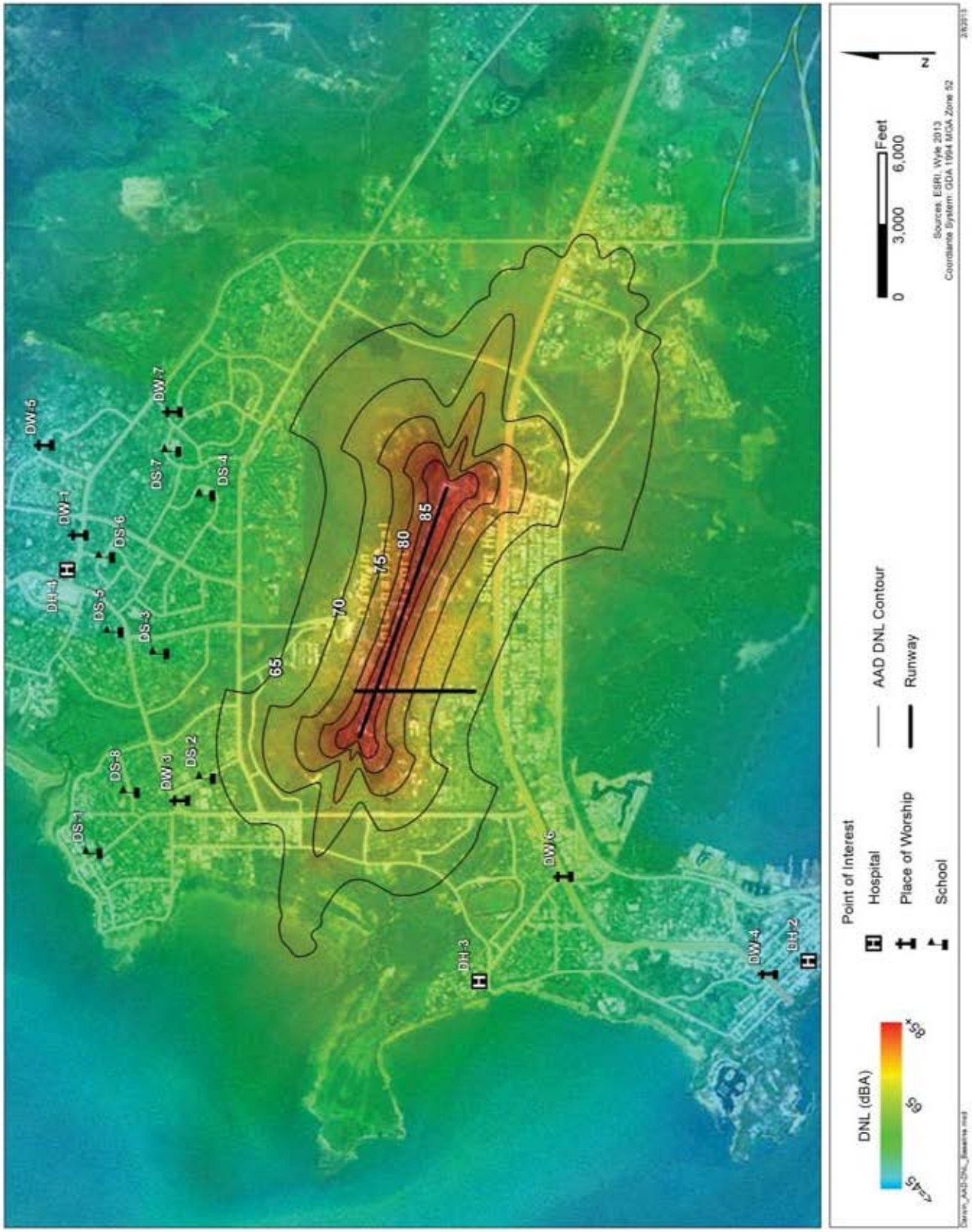

Figure 3-3. DNL Contours and Gradient for Baseline AAD Aircraft Operations at RAAF Darwin

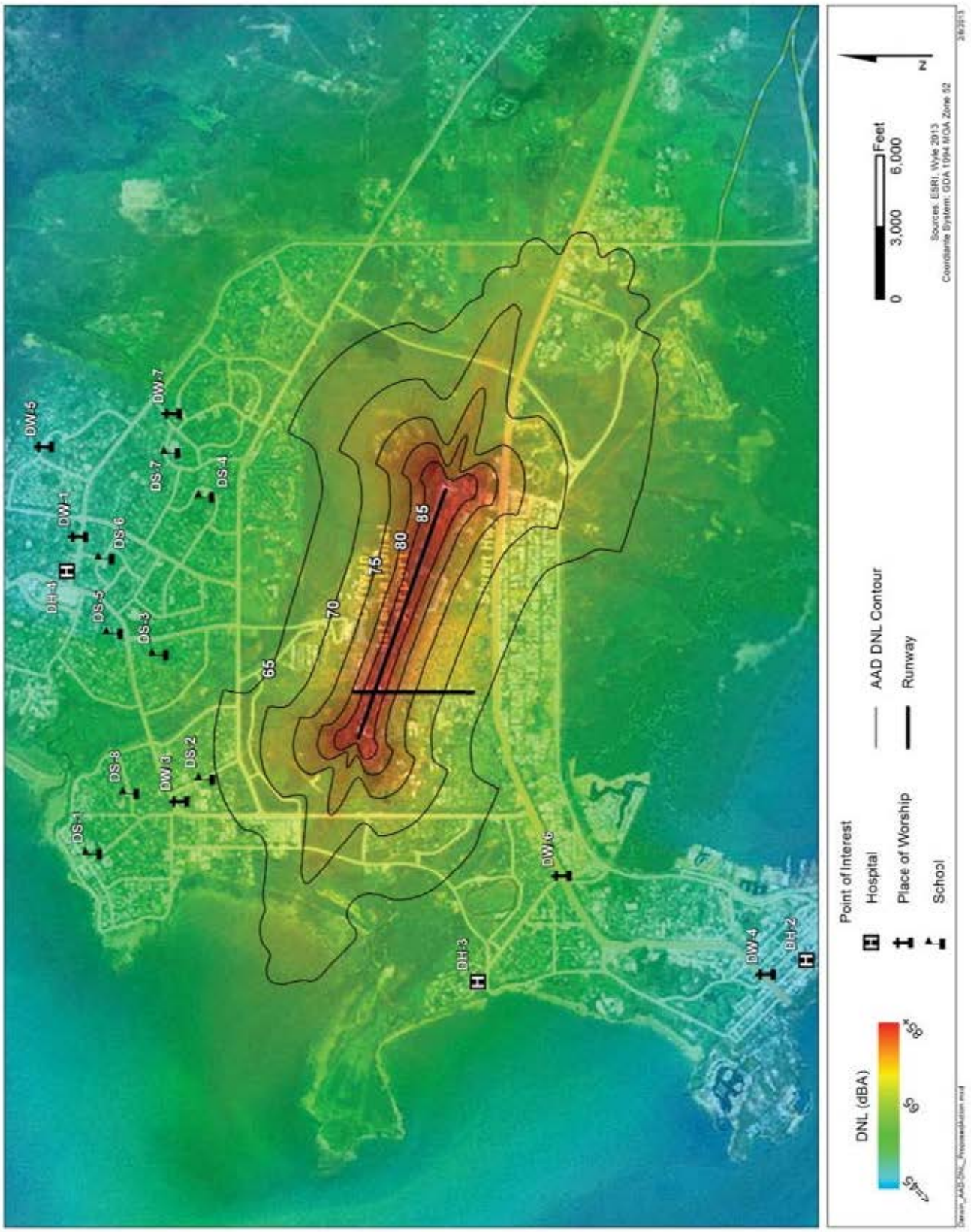

Figure 3-4. DNL Contours and Gradient for Proposed Action AAD Aircraft Operations at RAAF Darwin

Figure 3-5. Comparison of Baseline and Proposed Action DNL Contours for AAD Aircraft Operations at RAAF Darwin

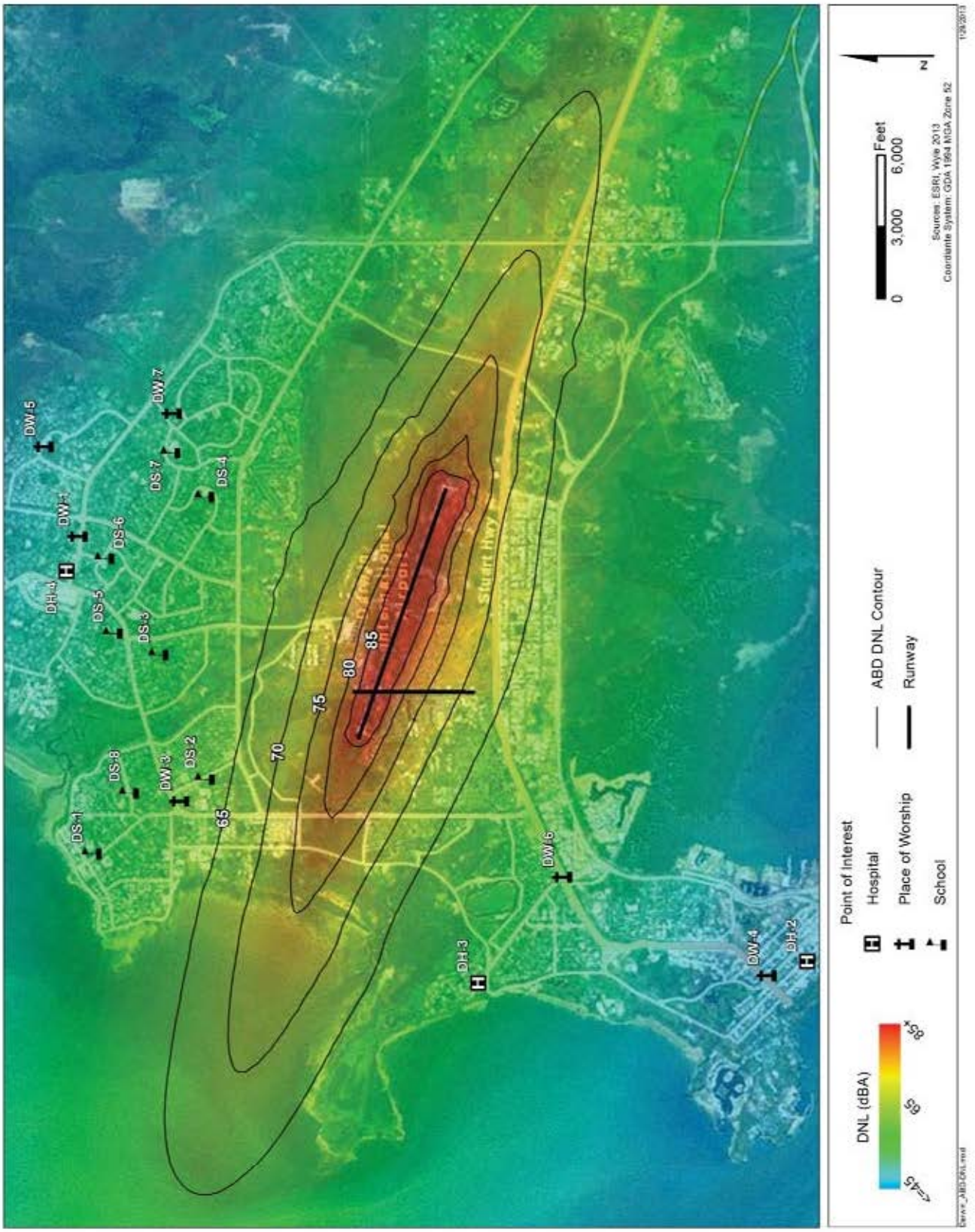

Figure 3-6. DNL Contours and Gradient for PACAF ABD Aircraft Operations at RAAF Darwin

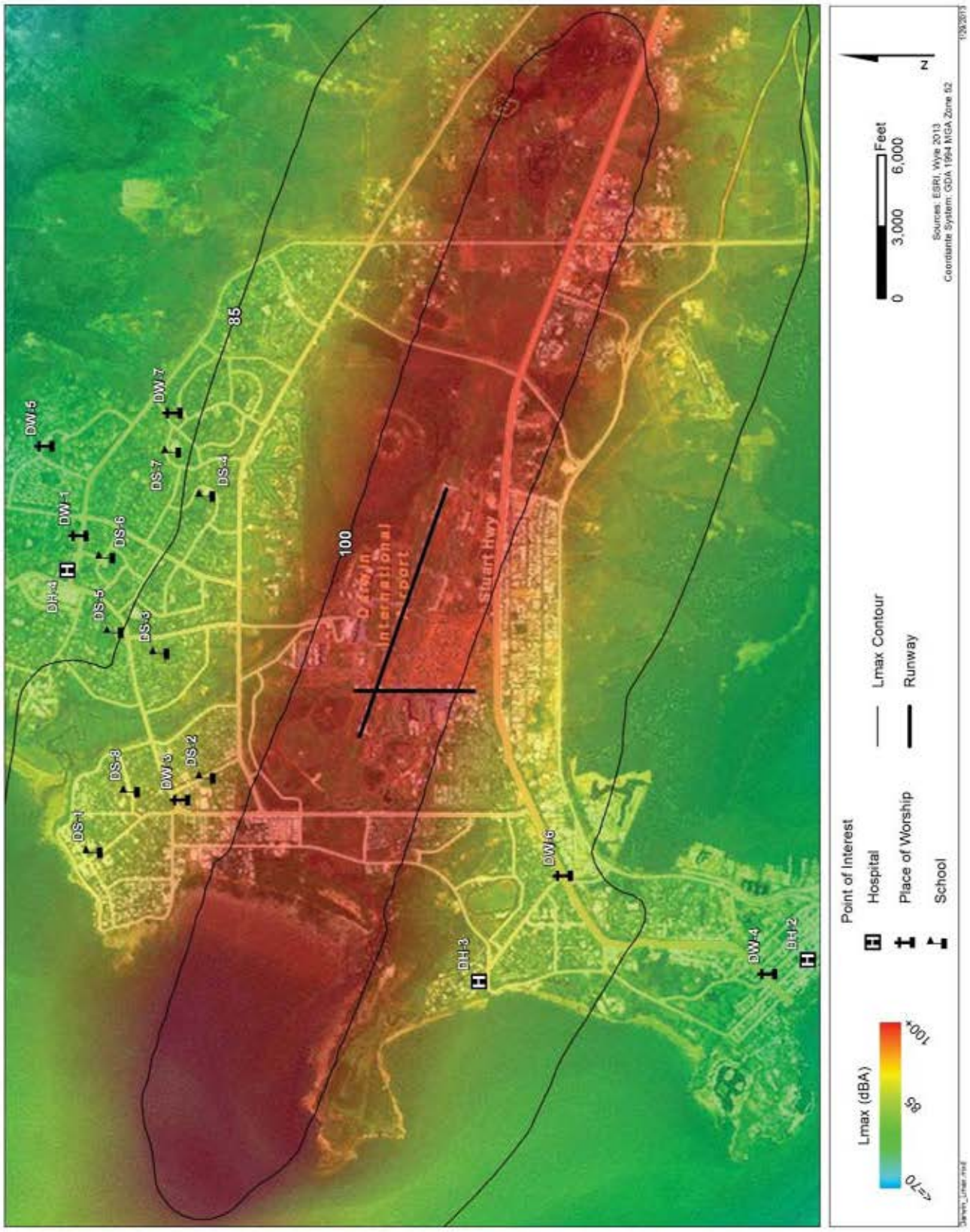

Figure 3-7. A-weighted Maximum Sound Level Contours and Gradient for PACAF Aircraft Operations at RAAF Darwin

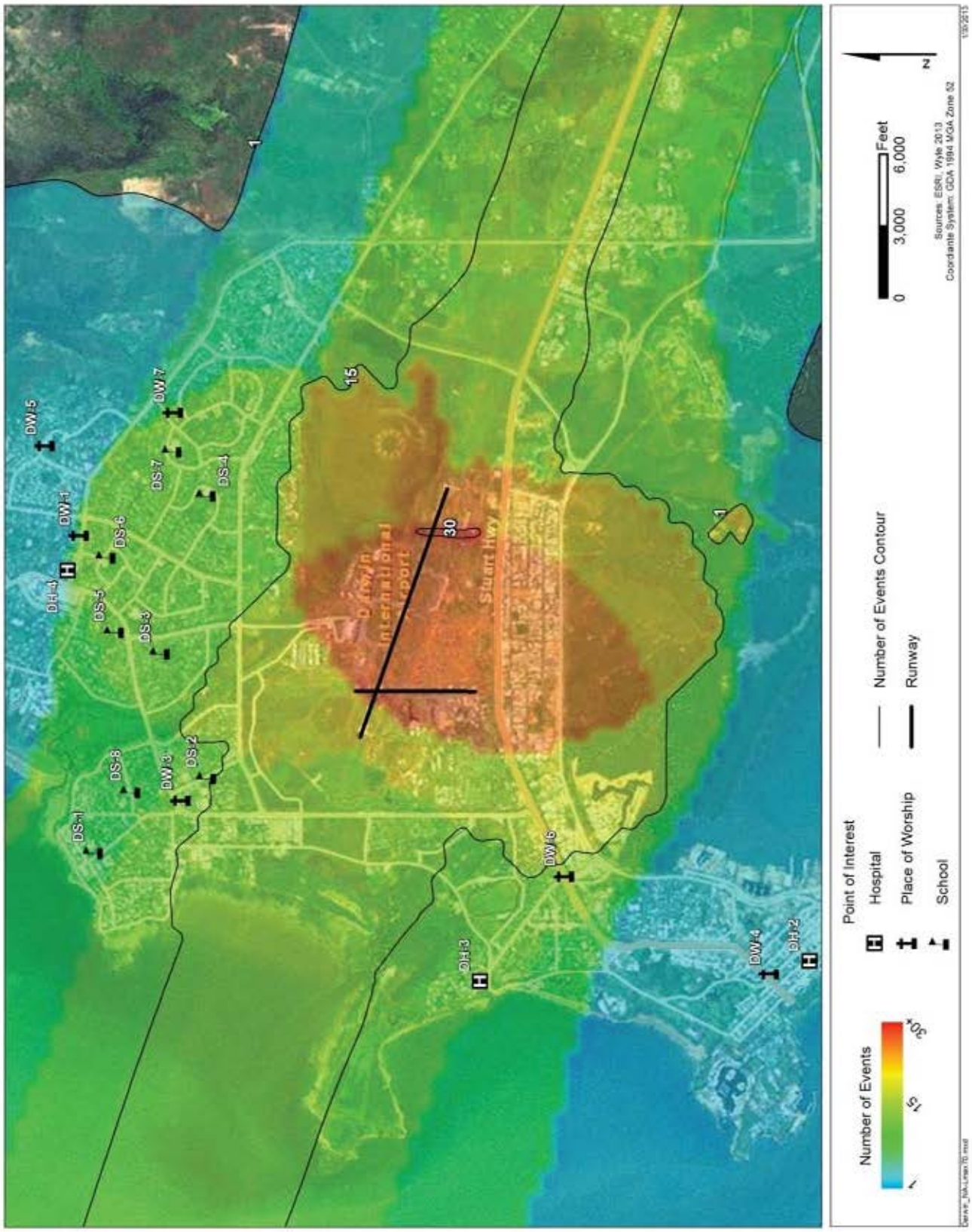

Figure 3-8. NA070ALM Contours and Gradient for ABD PACAF Aircraft Operations at RAAF Darwin

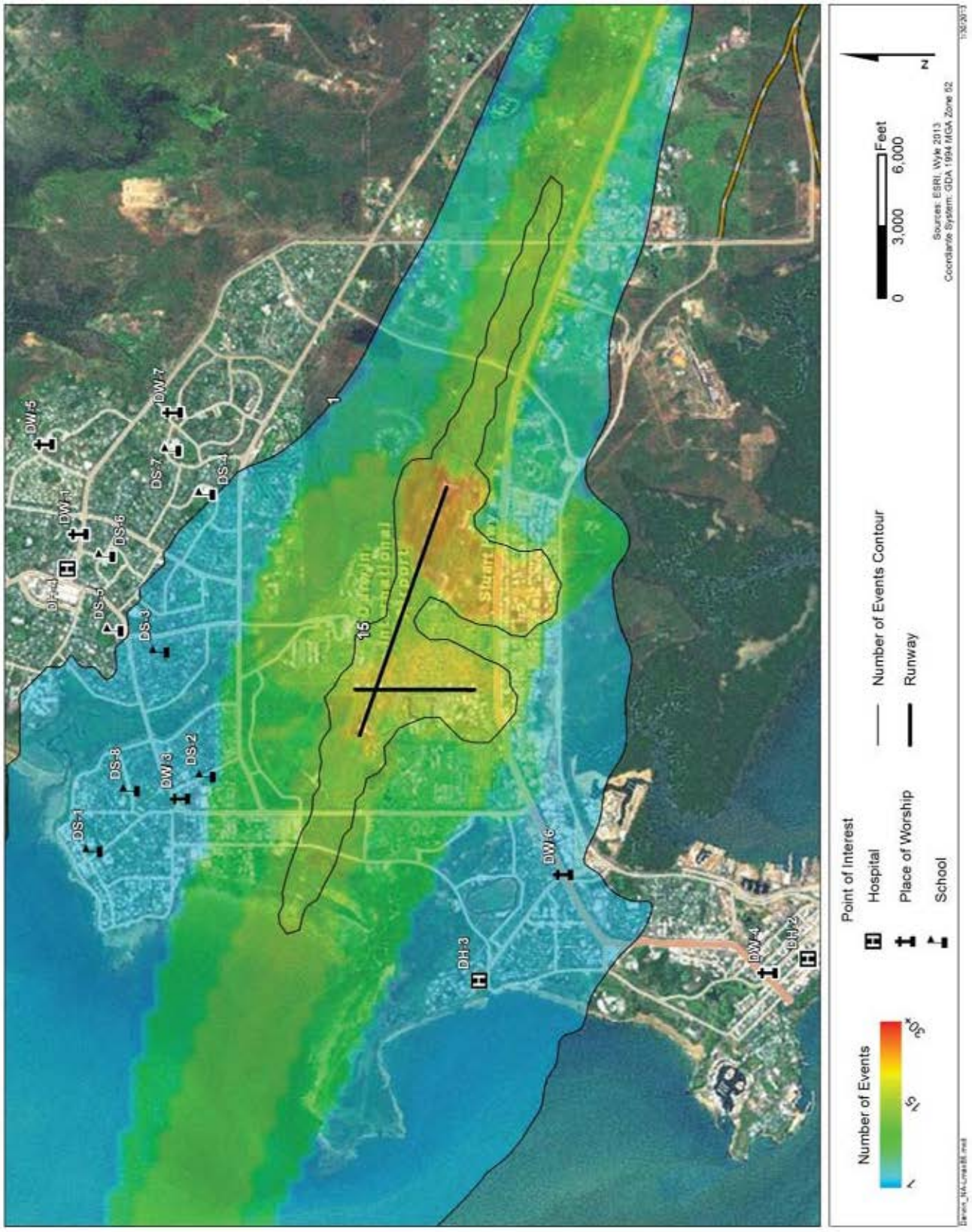

Figure 3-9. NA085ALM Contours and Gradient for ABD PACAF Aircraft Operations at RAAF Darwin

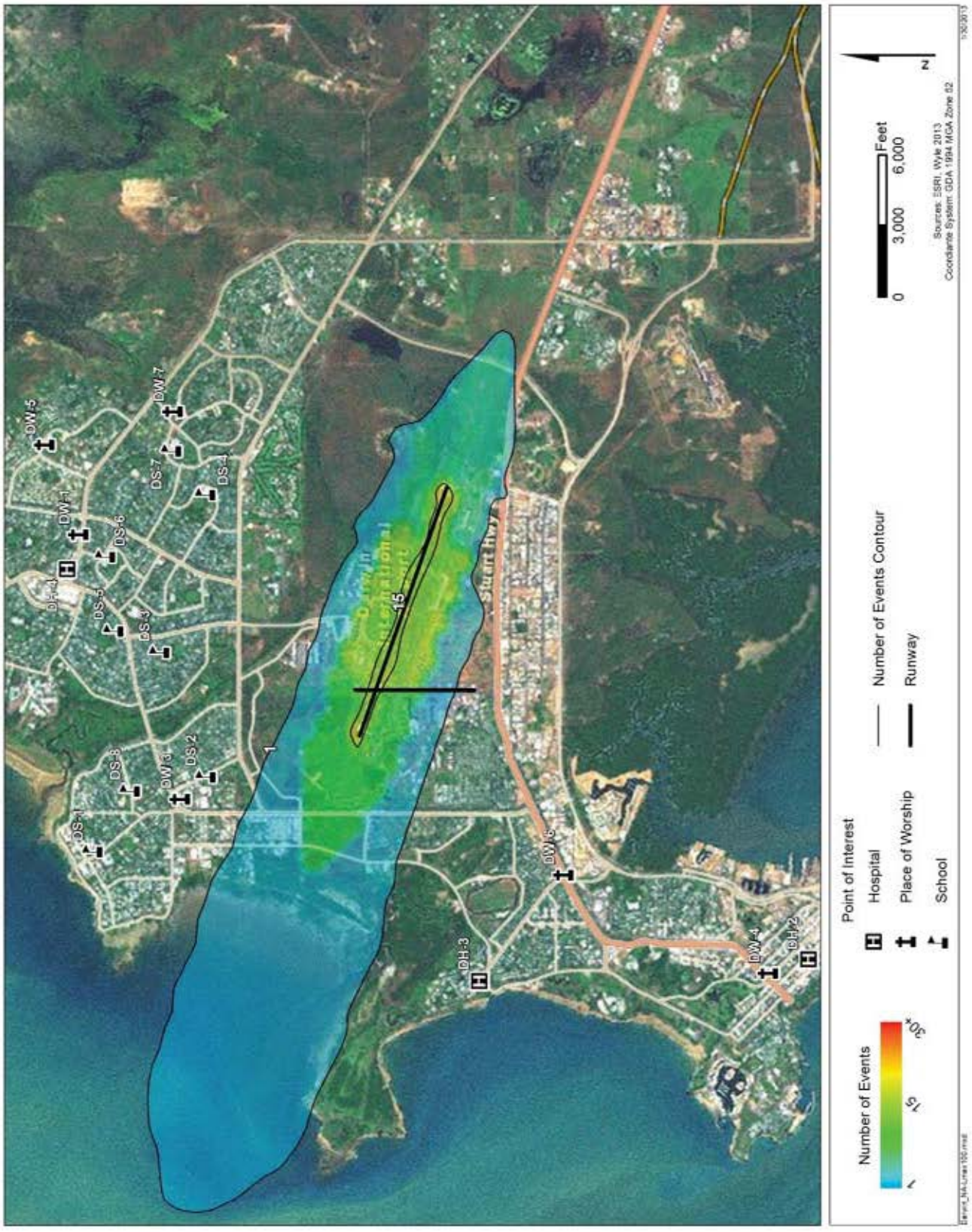

Figure 3-10. NA100ALM Contours and Gradient for ABD PACAF Aircraft Operations at RAAF Darwin

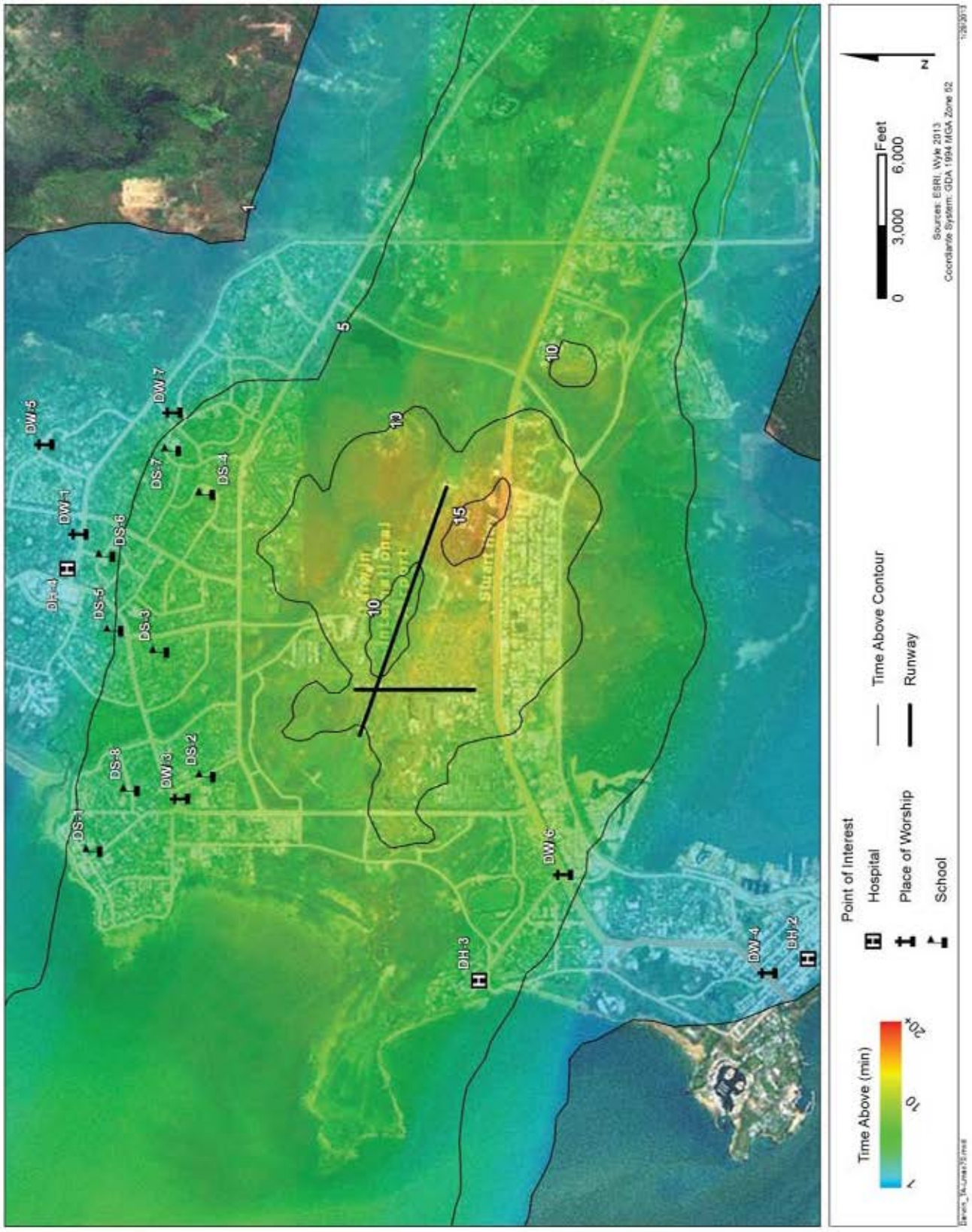

Figure 3-11. TA070 Contours and Gradient for ABD PACAF Aircraft Operations at RAAF Darwin

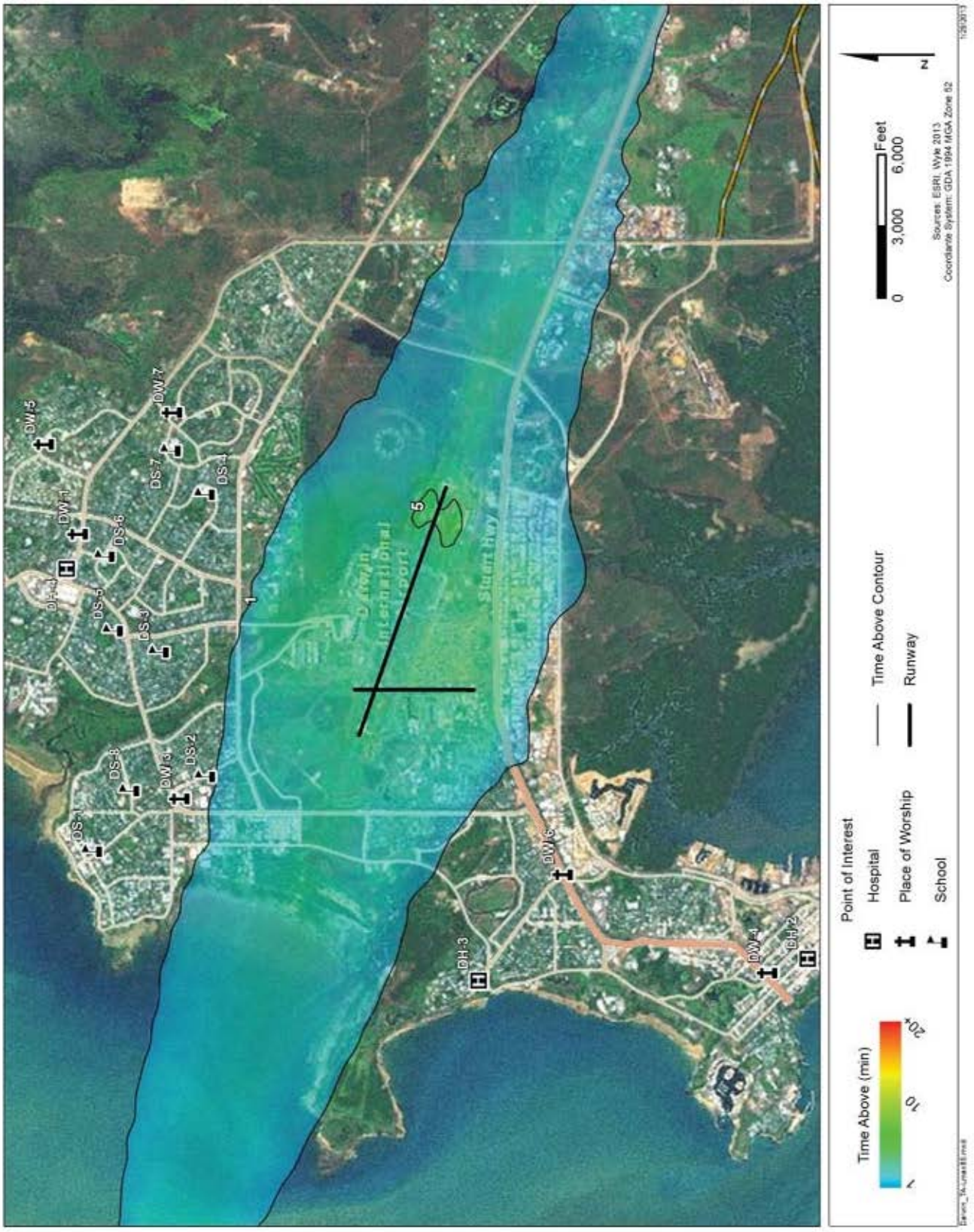

Figure 3-12. TA085 Contours and Gradient for ABD PACAF Aircraft Operations at RAAF Darwin

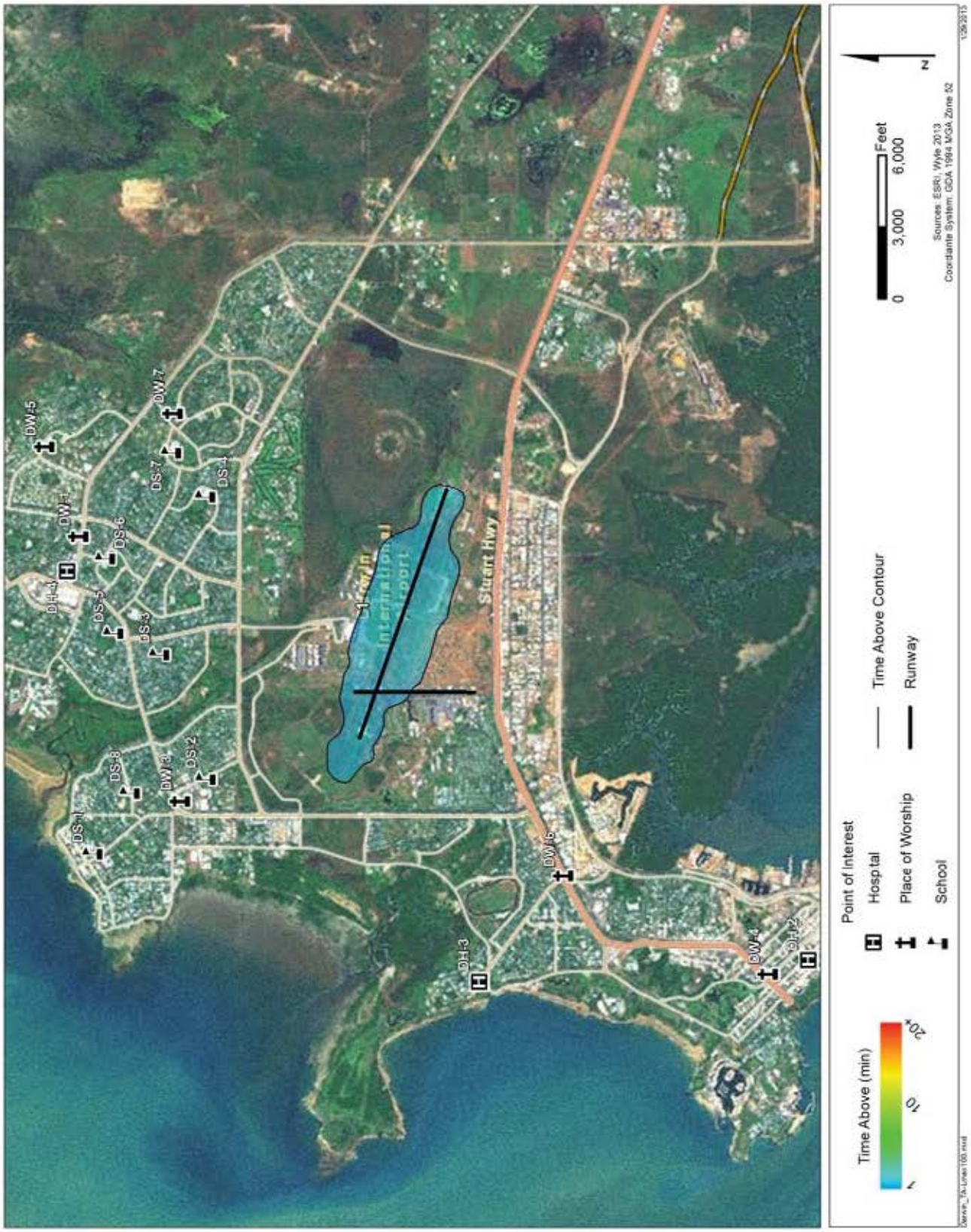

Figure 3-13. TA100 Contours and Gradient for ABD PACAF Aircraft Operations at RAAF Darwin

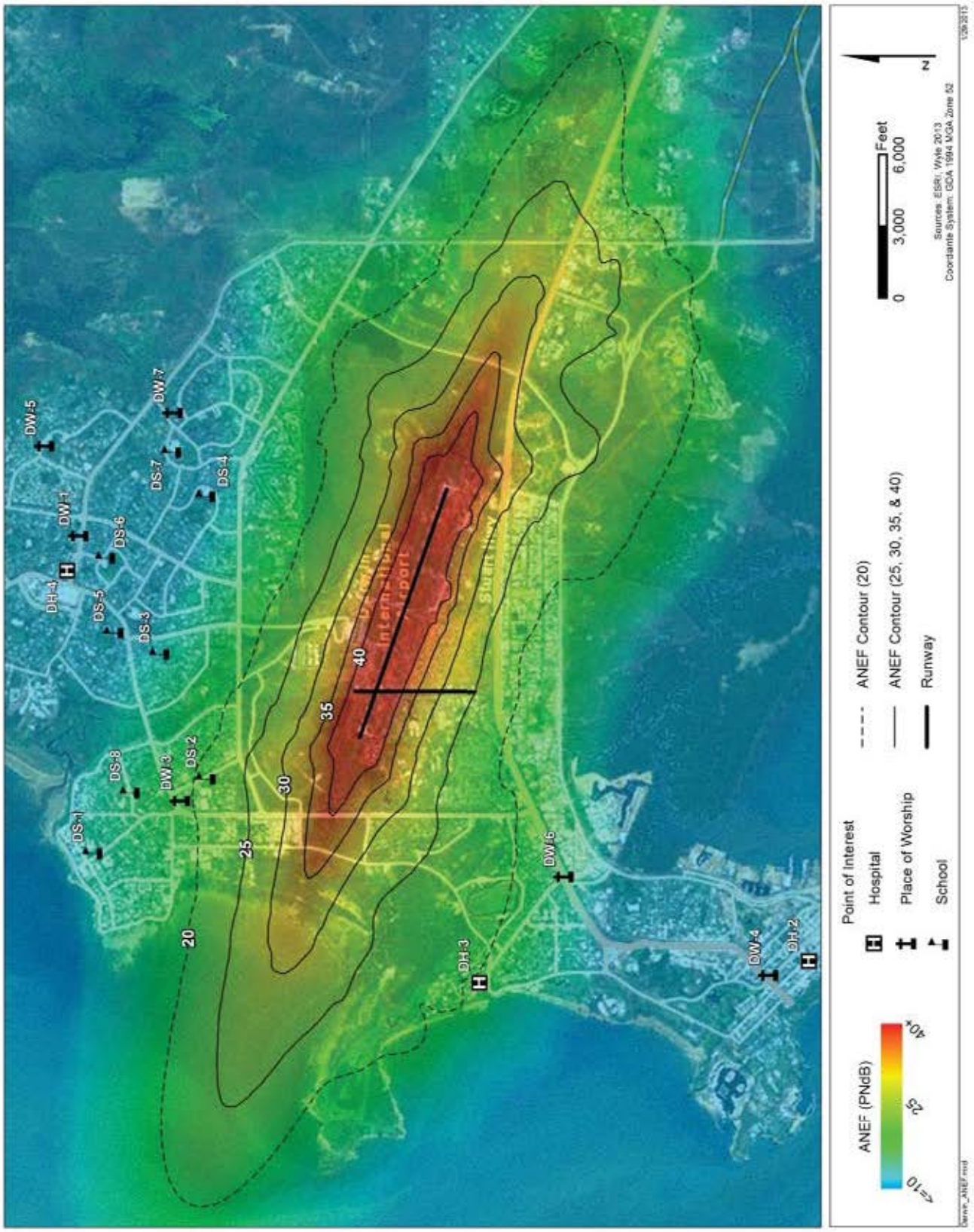

Figure 3-14. ANEC Contours and Gradient for Proposed Action AAD Aircraft Operations at RAAF Darwin

Figure 3-15. Representative Points of Interest for RAAF Darwin

Table 3-4. Noise Exposure at Representative POI for ABD Aircraft Operations at RAAF Darwin

POI		DNL (dB)	Lmax (dB)	NA (events)			TA (minutes)		
ID	Description			70 dB Lmax	85 dB Lmax	100 dB Lmax	70 dB Lmax	85 dB Lmax	100 dB Lmax
DH-1	Royal Darwin Hospital	<45	80	2	0	0	1.4	0	0
DH-2	Darwin City Medical Centre	<45	79	2	0	0	1.2	0	0
DH-3	Darwin Day Surgery	57	90	13	1	0	6.4	0.5	0
DH-4	Top End Medical Centre	50	81	10	0	0	2.4	0	0
DS-1	Nightcliff Middle School	55	89	9	1	0	5.6	0.4	0
DS-2	Millner Primary School	63	94	14	1	0	7.7	0.7	0
DS-3	Jingili Primary School	57	87	14	1	0	7.2	0.4	0
DS-4	Anula Primary School	56	86	14	1	0	8.5	0.2	0
DS-5	Alawa Primary School	54	85	14	0	0	4.8	0	0
DS-6	Wagaman Primary School	52	83	14	0	0	4.4	0	0
DS-7	Sanderson Middle School	53	84	14	0	0	6.1	0	0
DS-8	Northern Territory Open Education Centre	57	90	10	1	0	6.0	0.5	0
DW-1	Islamic Society of Darwin	50	81	10	0	0	2.4	0	0
DW-2	Christ Cathedral Anglican	<45	77	2	0	0	1.3	0	0
DW-3	Lutheran Church of Australia	61	93	14	1	0	7.1	0.8	0
DW-4	Greek Orthodox Church	<45	80	2	0	0	1.2	0	0
DW-5	Abundant Life Christian Church	46	78	2	0	0	2.1	0	0
DW-6	Darwin Baptist Church	55	87	14	1	0	6.7	0.4	0
DW-7	Assemblies of God	52	84	14	0	0	4.0	0	0

Table 3-5. Noise Exposure at Representative POI for AAD Aircraft Operations at RAAF Darwin

Point of Interest		DNL (dBA)			ANEF (PNdB)		
ID	Description	Baseline	Baseline + Proposed Action	Increase re Baseline (dB)	2030 ANEF	2030 ANEF + Proposed Action	Increase re 2030 ANEF (PNdB)
DH-1	Royal Darwin Hospital	45.7	45.9	0.2	0	1	1
DH-2	Darwin City Medical Centre	45.9	46.0	0.1	0	1	1
DH-3	Darwin Day Surgery	60.7	60.8	0.1	18	19	1
DH-4	Top End Medical Centre	49.7	50.0	0.3	1	3	2
DS-1	Nightcliff Middle School	54.8	55.2	0.4	6	13	7
DS-2	Millner Primary School	63.7	64.0	0.3	15	21	6
DS-3	Jingili Primary School	56.4	56.8	0.4	8	12	4
DS-4	Anula Primary School	56.1	56.4	0.3	8	10	2
DS-5	Alawa Primary School	53.1	53.5	0.4	4	8	4
DS-6	Wagaman Primary School	51.4	51.7	0.3	3	5	2
DS-7	Sanderson Middle School	53.6	53.9	0.3	4	7	3
DS-8	Northern Territory Open Education Centre	58.1	58.4	0.3	9	15	6
DW-1	Islamic Society of Darwin	50.0	50.3	0.3	1	3	2
DW-2	Christ Cathedral Anglican	<45	<45	0.1	0	0	0
DW-3	Lutheran Church of Australia	61.2	61.5	0.3	13	19	6
DW-4	Greek Orthodox Church	47.1	47.2	0.1	0	1	1
DW-5	Abundant Life Christian Church	47.9	48.2	0.3	0	1	1
DW-6	Darwin Baptist Church	58.9	59.0	0.1	14	15	1
DW-7	Assemblies of God	53.9	54.1	0.2	4	7	3

Note: see Table 2-2 for composition of scenarios

4.0 RAAF Tindal

RAAF Tindal is a relatively isolated RAAF base. The nearest town, Katherine, is approximately 16 km (10 mi) from RAAF Tindal with a population of approximately 6,000 persons (Robinson 2012a).

The following three subsections detail the modeling data and the resultant noise exposure in the vicinity of RAAF Tindal.

4.1 Modeling Data

As provided by PACAF (Robinson 2012b), Table 4-1 details the proposed flight operations at RAAF Tindal which would total just over 1,000 annual PACAF military operations. The same flight operations are conducted at Tindal as Darwin. There would be two exercises per year, and each exercise would last 15 days resulting in a total of 30 operating days per year for PACAF aircraft at RAAF Tindal. The temporal utilization of each aircraft group was provided by interviews with RAAF (Robinson 2012a). No departure flight operations occurring during the DNL nighttime period (10:00 p.m. to 7:00 a.m.) are anticipated. Two percent of Fighter and Reconnaissance arrivals would be during the DNL nighttime period whereas five percent of Tanker and Bomber arrivals would be during the DNL nighttime period. No pattern operations are forecast.

The Fighters would perform only pitch-out arrivals with no straight-in arrivals while the Tankers and Bombers would perform only straight-in arrivals.

The runway and flight track utilization percentages are listed in Table 4-2. For each operation type and all four modeled aircraft types, Runways 14 and 32 would be used for 95 percent of flight operations, respectively (Robinson 2012a).

Table 4-2 also lists the flight track utilization. As there would only be one flight track per combination of operation type and runway, this portion of Table 4-2 is blank. The modeled flight tracks for the PACAF aircraft at Tindal are presented in Figure 4-1. The modeled arrival and departure KC-10, B-1 and RQ-4 flight tracks are straight-out departures and straight-in arrivals. The modeled F-22 departures are straight-out. The modeled F-22 arrivals are pitch-out arrivals derived from a Wyle F-22 pilot (Batterton 2013a) which break at the beginning of the runway, have an abeam distance of 1 nm, a 1 nm downwind segment, and a 1 nm final leg.

With regard to flight profile utilization in Table 4-2, the Bomber category was modeled with the B-1 aircraft type. As such, it was assumed all B-1 departures would employ afterburner takeoffs. Conversely, the Fighter category is assumed to never utilize afterburners on takeoff. Representative profiles for each modeled aircraft type are presented in Appendix B. F-22 profiles were reviewed and modified via flight simulator by a Wyle F-22 pilot (Batterton 2013b).

As NOISEMAP requires events to be input on an average daily basis, the annual flight operations of Table 4-1 were divided by the number of flying days shown in Table 4-1 for the ABD case (and the L_{max}, TA and NA metrics) or by 365 for the AAD DNL case.

Run-ups are events that take place with the aircraft parked on the ground and the engine running to conduct various pre-flight checks, tests or repairs. Sometimes the engine may be removed from the aircraft, but for all run-ups at Tindal, the engines would remain in-frame.

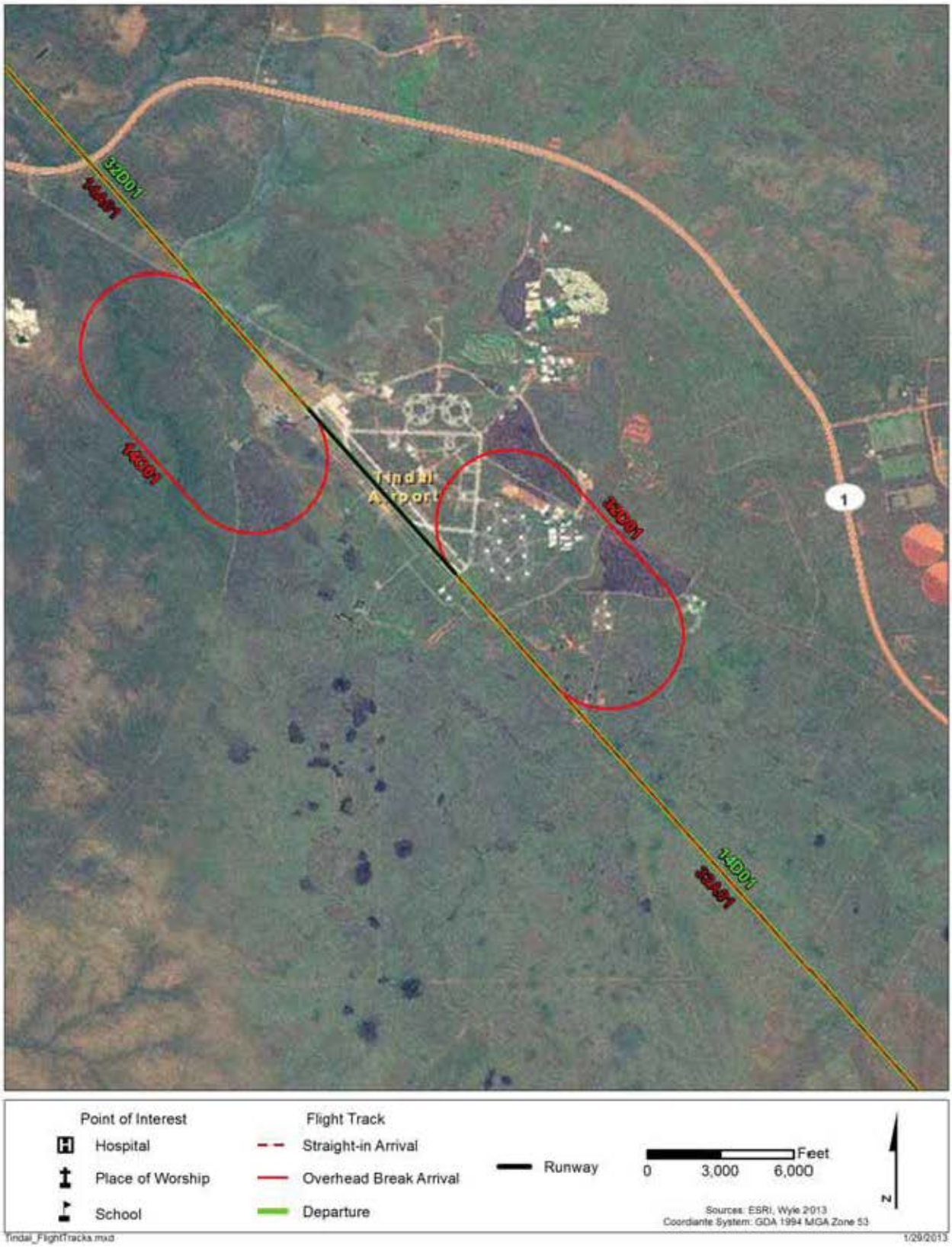

Figure 4-1. Modeled Flight Tracks at RAAF Tindal

Figure 4-2. Modeled PACAF Aircraft Run-up Locations at RAAF Tindal

Table 4-1. Annual Flight Operations for PACAF Exercises at RAAF Tindal (2 x 15 day Exercises per Year)

Group	Modeled Aircraft Type	Number of Flying Days (1)	Temporal Departure Utilization			Temporal Arrival Utilization		
			Day (0700-1900)	Evening (1900-2200)	Night (2200-0700)	Day (0700-1900)	Evening (1900-2200)	Night (2200-0700)
Fighter (F-15E, F-22)	F-22	30	95%	5%	0%	90%	8%	2%
Tanker (KC-10)	KC-10A	30	95%	5%	0%	55%	40%	5%
Bomber (B-1, B-52)	B-1	30	95%	5%	0%	55%	40%	5%
Reconnaissance (RQ-4)	CITX	30	95%	5%	0%	90%	8%	2%

Group	Modeled Aircraft Type	Number of Flying Days (1)	Departure				Straight-in Arrival				Pitch-out Arrival				Total			
			Day (0700-1900)	Evening (1900-2200)	Night (2200-0700)	Total	Day (0700-2200)	Evening (1900-2200)	Night (2200-0700)	Total	Day (0700-2200)	Evening (1900-2200)	Night (2200-0700)	Total	Day (0700-2200)	Evening (1900-2200)	Night (2200-0700)	Total
Fighter (F-15E, F-22)	F-22	30	342	18	-	360	-	-	-	-	324	29	7	360	666	47	7	720
Tanker (KC-10)	KC-10A	30	57	3	-	60	33	24	3	60	-	-	-	-	90	27	3	120
Bomber (B-1, B-52)	B-1	30	57	3	-	60	33	24	3	60	-	-	-	-	90	27	3	120
Reconnaissance (RQ-4)	CITX	30	57	3	-	60	54	5	1	60	-	-	-	-	111	8	1	120
TOTAL			**513**	**27**	**-**	**540**	**120**	**53**	**7**	**180**	**324**	**29**	**7**	**360**	**957**	**109**	**14**	**1,080**

Note:
1) 2 exercises per year, 15 days per exercise

Table 4-2. Runway and Flight Track Utilization for Modeled PACAF Aircraft at RAAF Tindal

		Runway				Flight Track						Profile					
			Percentages (1)					Percentages (2) (if not 100%)					Percentages (3) (if not 100%)				
Aircraft ID	Operation Type	ID	Day (0700-1900)	Evening (1900-2200)	Night (2200-0700)	ID	Description	Day (0700-1900)	Evening (1900-2200)	Night (2200-0700)		ID	Description	Day (0700-1900)	Evening (1900-2200)	Night (2200-0700)	
F-22	Departure	14	95%	95%	95%	14D01	Straight-out Departure					100	MIL Departure				
			95%	95%	95%							101	A/B Departure	0%	0%	0%	
		32	5%	5%	5%	32D01	Straight-out Departure					102	MIL Departure				
			5%	5%	5%							103	A/B Departure	0%	0%	0%	
	Straight-in Arrival	14	0%	0%	0%	14A01	Straight-in Arrival										
		32	0%	0%	0%	32A01	Straight-in Arrival										
	Pitch-out Arrival	14	95%	95%	95%	14O01	Pitch-out Arrival; Break at the numbers, 1 NM Abeam, 1 NM Downwind, 1 NM Final					120	Standard Arrival				
		32	5%	5%	5%	32O01	Pitch-out Arrival; Break at the numbers, 1 NM Abeam, 1 NM Downwind, 1 NM Final					121	Standard Arrival				
KC-10A	Departure	14	95%	95%	95%	14D01	Straight-out Departure					200	Standard Departure				
		32	5%	5%	5%	32D01	Straight-out Departure					201	Standard Departure				
	Straight-in Arrival	14	95%	95%	95%	14A01	Straight-in Arrival					210	Standard Arrival				
		32	5%	5%	5%	32A01	Straight-in Arrival					211	Standard Arrival				
B-1	Departure	14	95%	95%	95%	14D01	Straight-out Departure					300	A/B Departure				
		32	5%	5%	5%	32D01	Straight-out Departure					301	A/B Departure				
	Straight-in Arrival	14	95%	95%	95%	14A01	Straight-in Arrival					310	Standard Arrival				
		32	5%	5%	5%	32A01	Straight-in Arrival					311	Standard Arrival				
CITX	Departure	14	95%	95%	95%	14D01	Straight-out Departure					400	Standard Departure				
		32	5%	5%	5%	32D01	Straight-out Departure					401	Standard Departure				
	Straight-in Arrival	14	95%	95%	95%	14A01	Straight-in Arrival					410	Standard Arrival				
		32	5%	5%	5%	32A01	Straight-in Arrival					411	Standard Arrival				

Note:
1) within runway group
2) within specific runway
3) within specific flight track

At RAAF Tindal, all four modeled aircraft perform various types of run-ups. Table 4-3 presents the annual run-up events for PACAF exercises at RAAF Tindal. Figure 4-2 presents the modeled run-up pad locations listed in Table 4-3. Same as at Darwin, all aircraft categories, except Reconnaissance, are expected to perform 5-minute pre-flight checks at the hammerheads of the runways. Fighters, Tankers and Bombers would perform "warm-up" run-ups prior to each departure at their respective ramp location. The F-22, KC-10, B-1 and T-45 warm-ups would be 15 minutes, 5 minutes, 30 minutes and 5 minutes, respectively. The B-1 would also conduct 5-minute "cool down" run-ups after each arrival. All of these run-ups would be at relatively low power settings.

Table 4-3. Annual PACAF Run-up Events at RAAF Tindal (2 x 15 Day Exercises per Year)

Group	Aircraft Type	Engine Type	Run-up Type	In-frame / Out-of-frame	Run-up Pad ID	Magnetic Heading (degrees)	Pad %	Annual Events				Power Setting	Duration (Minutes per event)	Engines Running (per event)
								Day (0700-1900)	Evening (1900-2200)	Night (2200-0700)	Total			
Fighter (F-15, F-22, F-16)	F-22	F119-PW-100	15 min Warm-up	In-frame	Fighters	180	100%	342	18	-	360	10% ETR	15	2
			Hammerhead pre-flight checks	In-frame	HH14F	220	95%	325	17	-	342	10% ETR	5	2
					HH32F	220	5%	17	1	-	18	10% ETR	5	2
Tanker (KC-135, KC-10)	KC-10A	CF6-50C2	5 min Warm-up	In-frame	BRA1	40	50%	29	2	-	31	24% N1	5	3
					BRA2	40	50%	29	2	-	31	24% N1	5	3
			Hammerhead pre-flight checks	In-frame	HH14	40	95%	54	3	-	57	24% N1	5	3
					HH32	40	5%	3	-	-	3	24% N1	5	3
Bomber (B-1, B-52)	B-1	F101-GE-100	30 min Warm-up / 5 min Cool-down	In-frame	BRA1	40	50%	29	2	-	31	80% RPM	30	4
							50%	17	12	2	31		5	4
					BRA2	40	50%	29	2	-	31	80% RPM	30	4
							50%	17	12	2	31		5	4
			Hammerhead pre-flight checks	In-frame	HH14	40	95%	54	3	-	57	80% RPM	5	4
					HH32	40	5%	3	-	-	3	80% RPM	5	4
Reconnais-sance (RQ-4)	T-45	F405-RR-401	5 min Warm-up	In-frame	RQ-4	220	100%	57	3	-	60	55% RPM	5	1

4.2 Noise Exposure

Baseline noise data was not available for RAAF Tindal. Several squadrons of fighter aircraft are based and exercises are hosted at Tindal. It is expected that the proposed PACAF exercises would be a relatively small contribution to the overall noise exposure. In lieu of baseline data, the noise analysis below only depicts the PACAF exercise.

Figure 4-3 shows the resultant 65 dB to 85 dB DNL contours in 5 dB increments for Tindal ABD PACAF exercises only. The 65 dB DNL contour would extend approximately 1.75 miles to the northwest from the approach end of Runway 14 and approximately 4 miles from the threshold of the approach end of Runway 32 to the southeast. The halfwidth of the 65 dB DNL contour, i.e., distance perpendicular to Runway 14/32, would be approximately 1 mile. The exposure would extend more to the southeast due to the runway utilization being heavily weighted to Runway 14.

Figure 4-4 shows the resultant 65 dB to 85 dB DNL contours in 5 dB increments for the Tindal AAD PACAF exercises only. It is anticipated the contours for AAD operations would be approximately 10 dB less than the contours for the ABD operations. The 65 dB DNL contour would extend approximately 2000 feet to the northwest from the approach end of Runway 14 and approximately 1.7 miles from the threshold of the approach end of Runway 32 to the southeast. The halfwidth of the 65 dB DNL contour would be approximately 2000 feet.

Among the PACAF aircraft, DNL exposure would be dominated nearly equally by the Fighter and Bomber flight operations.

Figures 4-5 through 4-11 show the 24-hour L_{max}, NA and TA contours and gradients for Tindal ABD PACAF exercises only, per Table 2-2.

Figure 4-12 shows the resultant 20 dB to 40 dB ANEC contours in 5 dB increments for Tindal ABD (30 days). Figure 3-5 includes only PACAF exercise aircraft. The 20 PNdB ANEC contour would extend approximately 2 miles to the northwest from the approach end of Runway 14 and approximately 4 miles

from the threshold of the approach end of runway 32 to the southeast. The halfwidth of the 20 PNdB ANEC contour would be approximately 1 mile. ANEC exposure would be primarily dominated by PACAF's Bomber flight operations.

The modeled POIs selected for RAAF Tindal were depicted in the aforementioned figures but are shown by themselves in their entirety in Figure 4-13. The POIs are located in the vicinity of the town of Katherine, 16 km northwest of Tindal, and consist of Katherine Hospital, two schools and two places of worship. None of the POIs are in proximity to the DNL and ANEC contours of Figures 4-3, 4-4 or 4-12.

Table 4-4 presents the noise metrics computed for ABD operations for each of 5 POI for RAAF Tindal. No POIs would be exposed to DNL greater than or equal to 65 dB. All POIs would have DNL less than 45 dB.

Table 4-4 also lists the L_{max}, NA and TA for each of the Tindal POI. L_{max} would range from 67 dB at TW-1 (Anglican Church of Australia) to 79 dB at TW-2 (Heritage Christian Church). Correspondingly, no events or time at or above 85 dB L_{max} would occur at the selected POI. The greatest NA 70 dB L_{max} would be less than 1 at TH-1, TS-2 and TW-2.

Table 4-5 presents the noise metrics computed for AAD operations for each of the 5 POI for RAAF Tindal. No POI would be exposed to DNL greater than or equal to 65 dB due to PACAF operations and no POI would be exposed to PACAF ANEC greater than or equal to 0 PNdB.

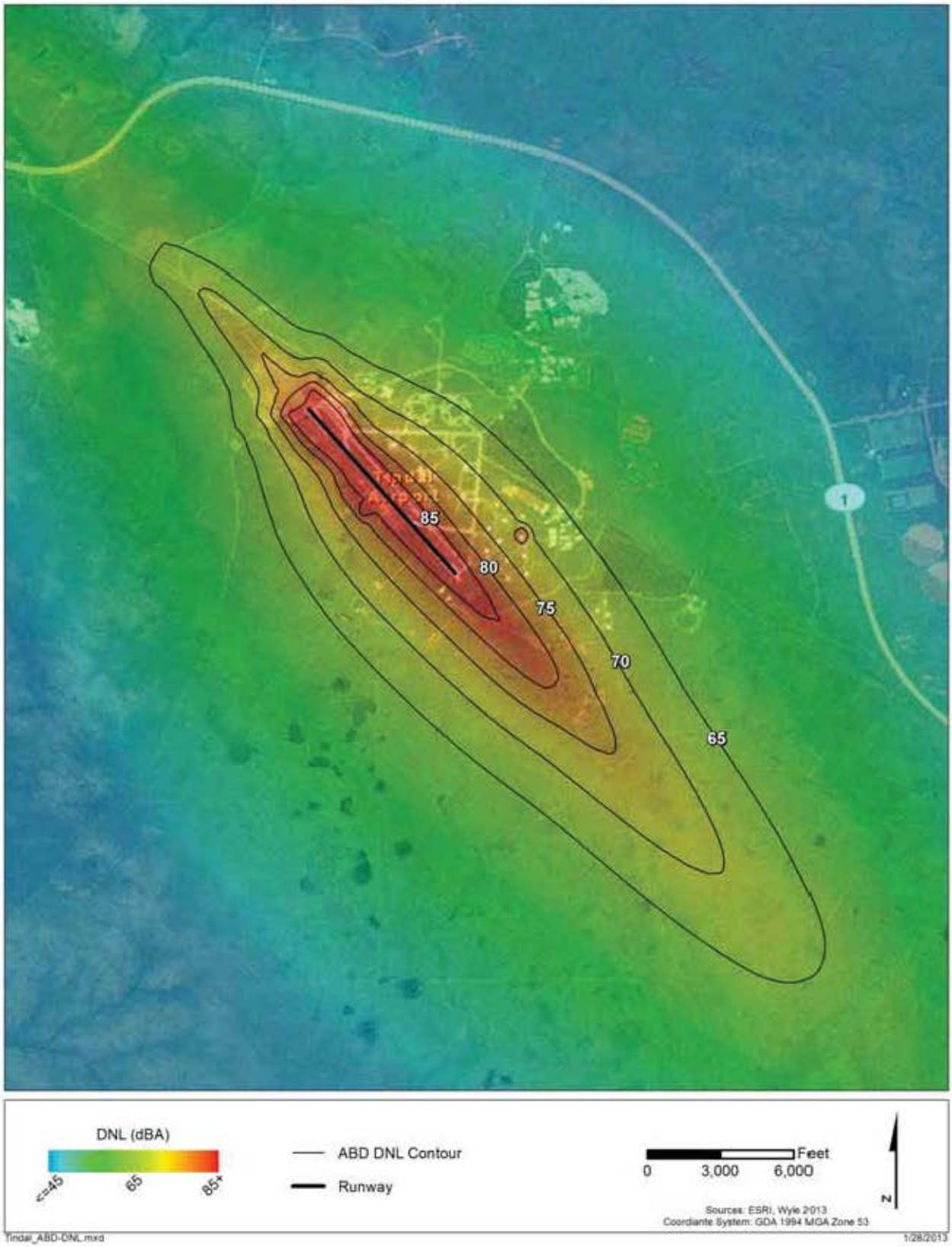

Figure 4-3. DNL Contours and Gradient for PACAF ABD Aircraft Operations at RAAF Tindal

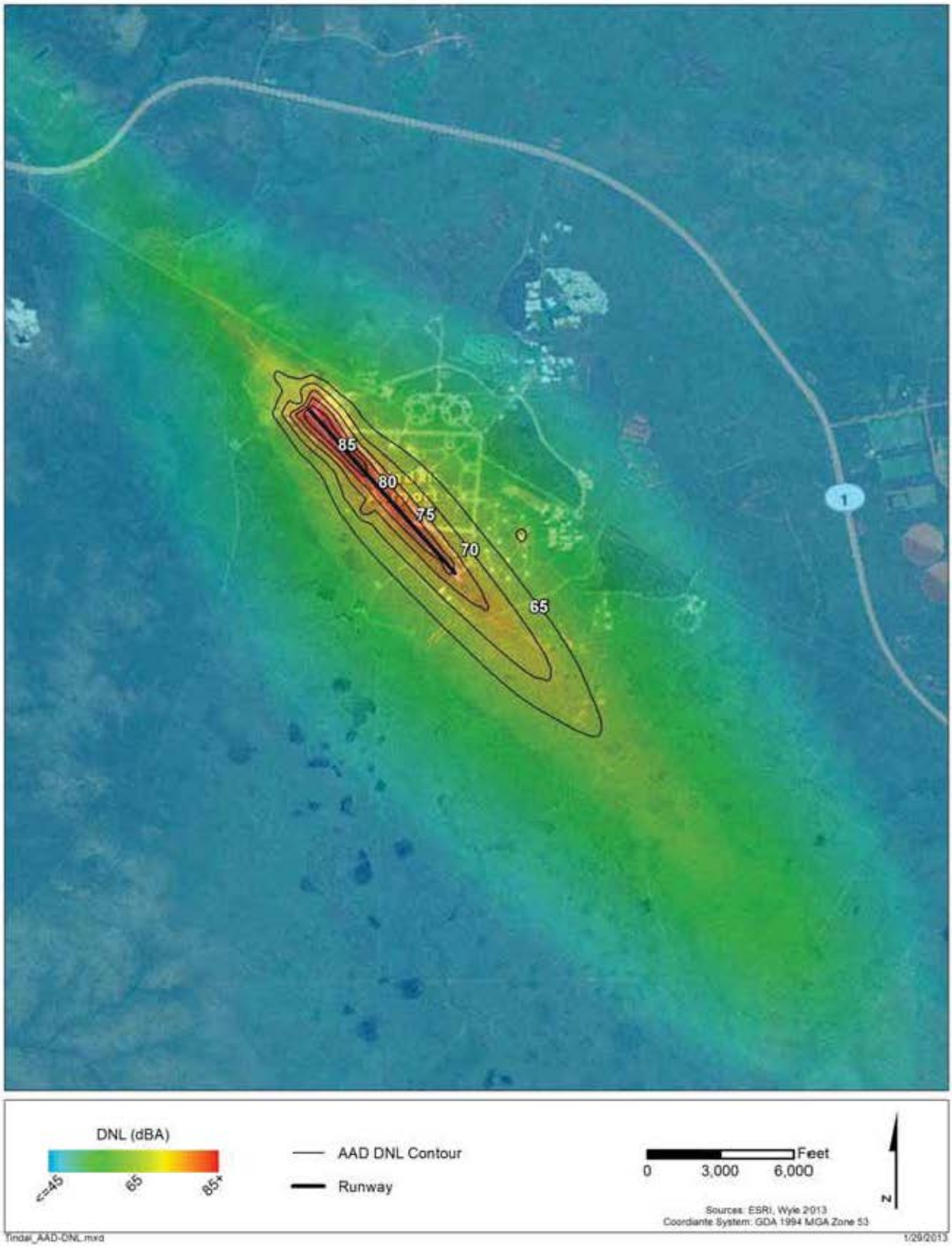

Figure 4-4. DNL Contours and Gradient for PACAF AAD Aircraft Operations at RAAF Tindal

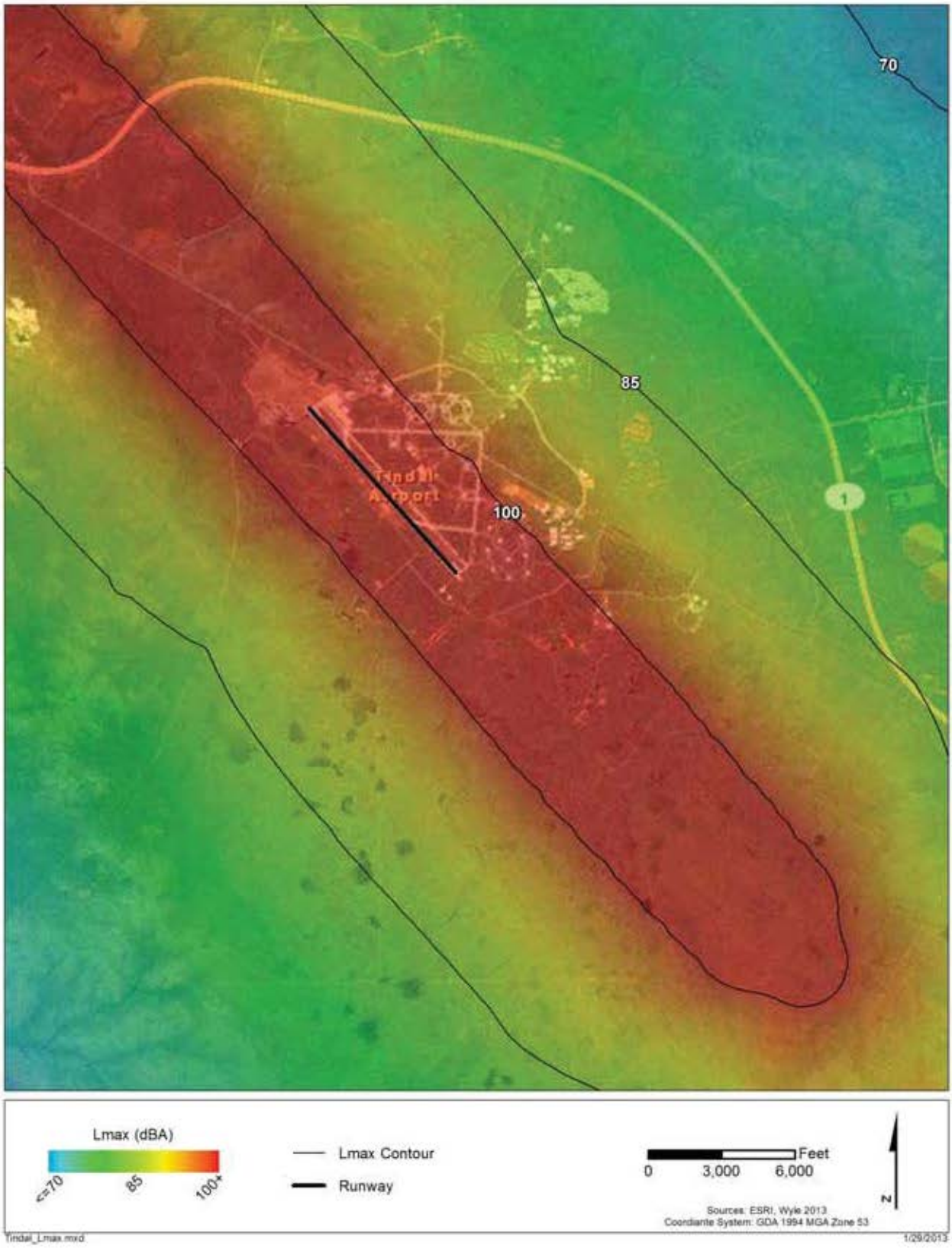

Figure 4-5. A-weighted Maximum Sound Level Contours and Gradient for PACAF Aircraft Operations at RAAF Tindal

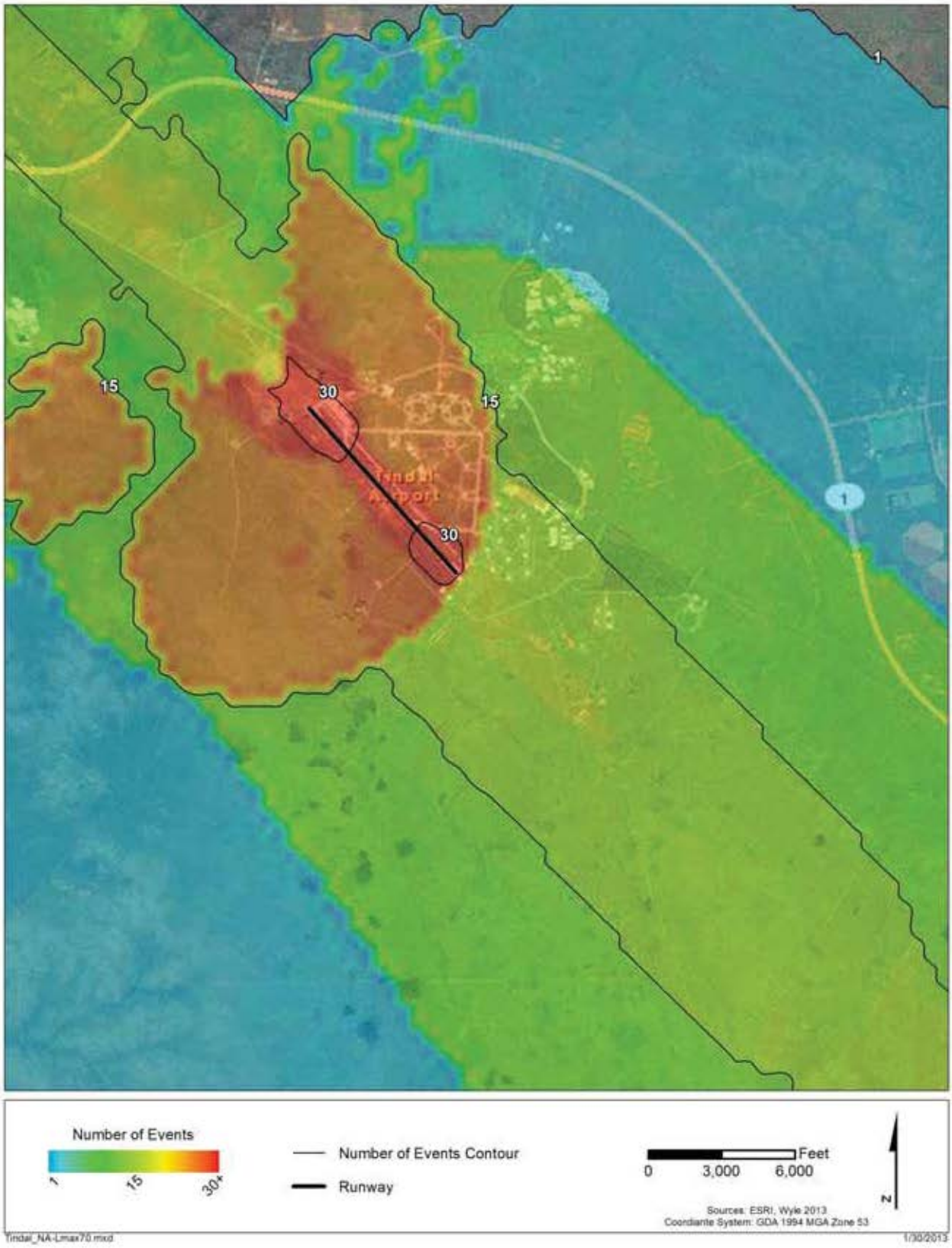

Figure 4-6. NA070ALM Contours and Gradient for ABD PACAF Aircraft Operations at RAAF Tindal

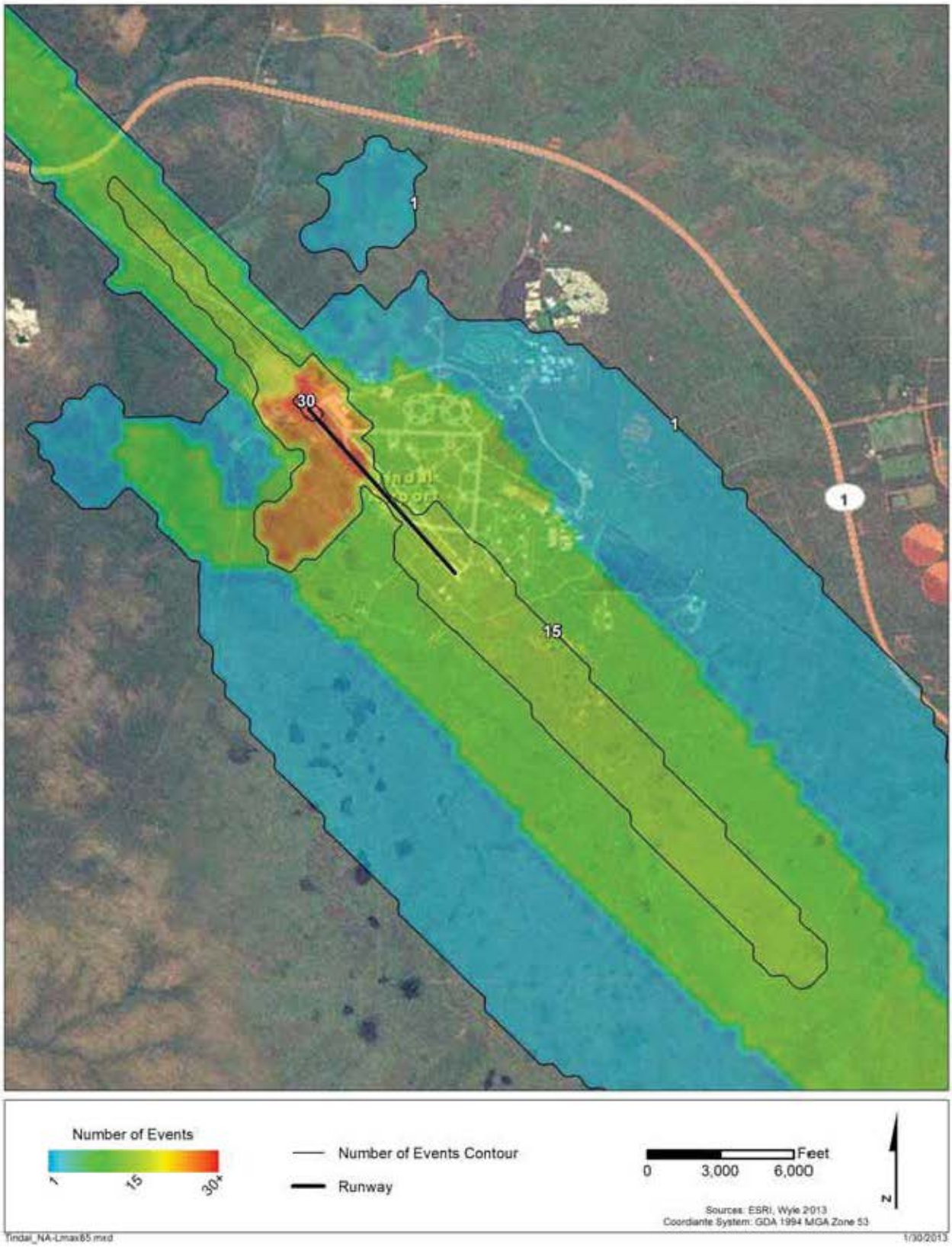

Figure 4-7. NA085ALM Contours and Gradient for ABD PACAF Aircraft Operations at RAAF Tindal

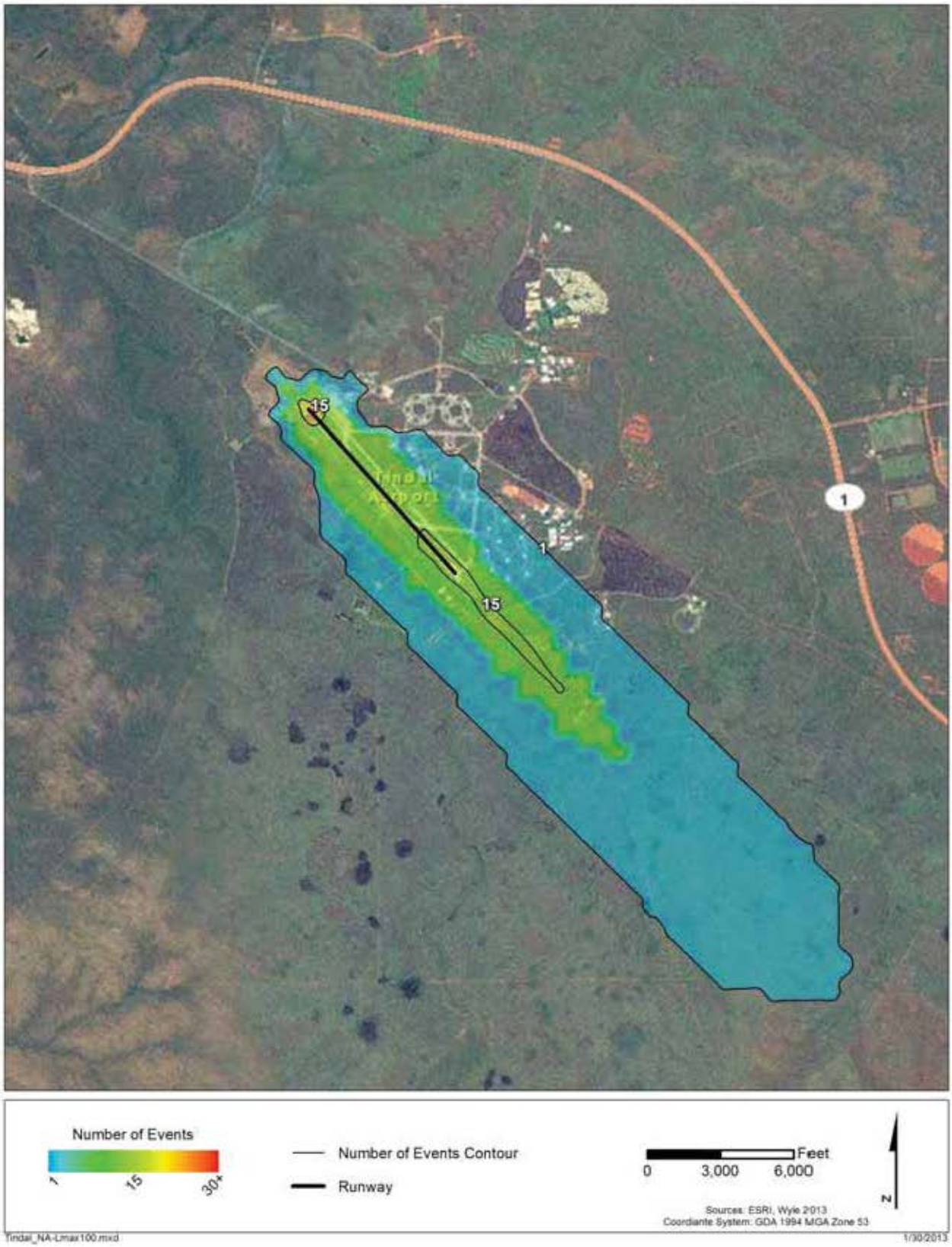

Figure 4-8. NA100ALM Contours and Gradient for ABD PACAF Aircraft Operations at RAAF Tindal

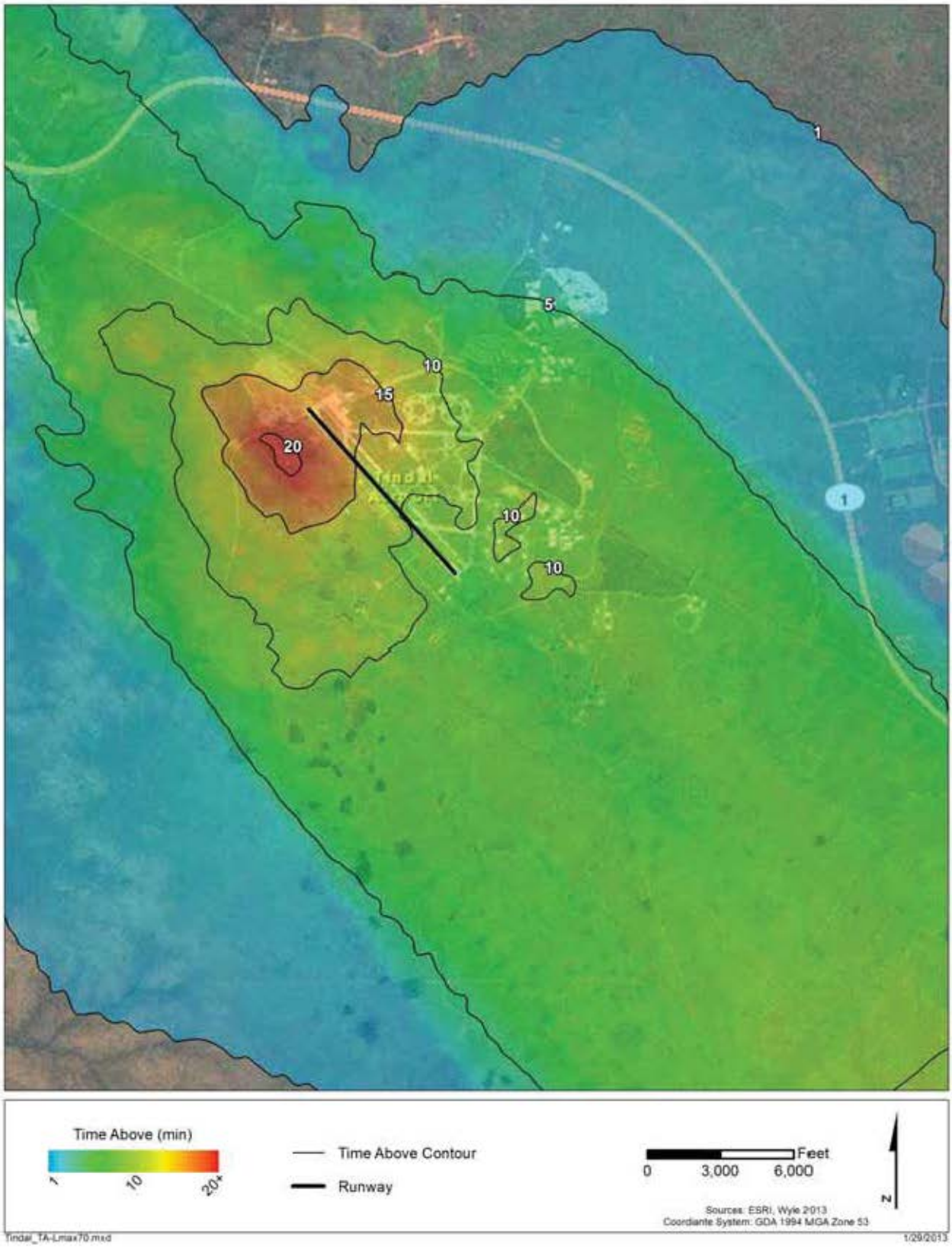

Figure 4-9. TA070 Contours and Gradient for ABD PACAF Aircraft Operations at RAAF Tindal

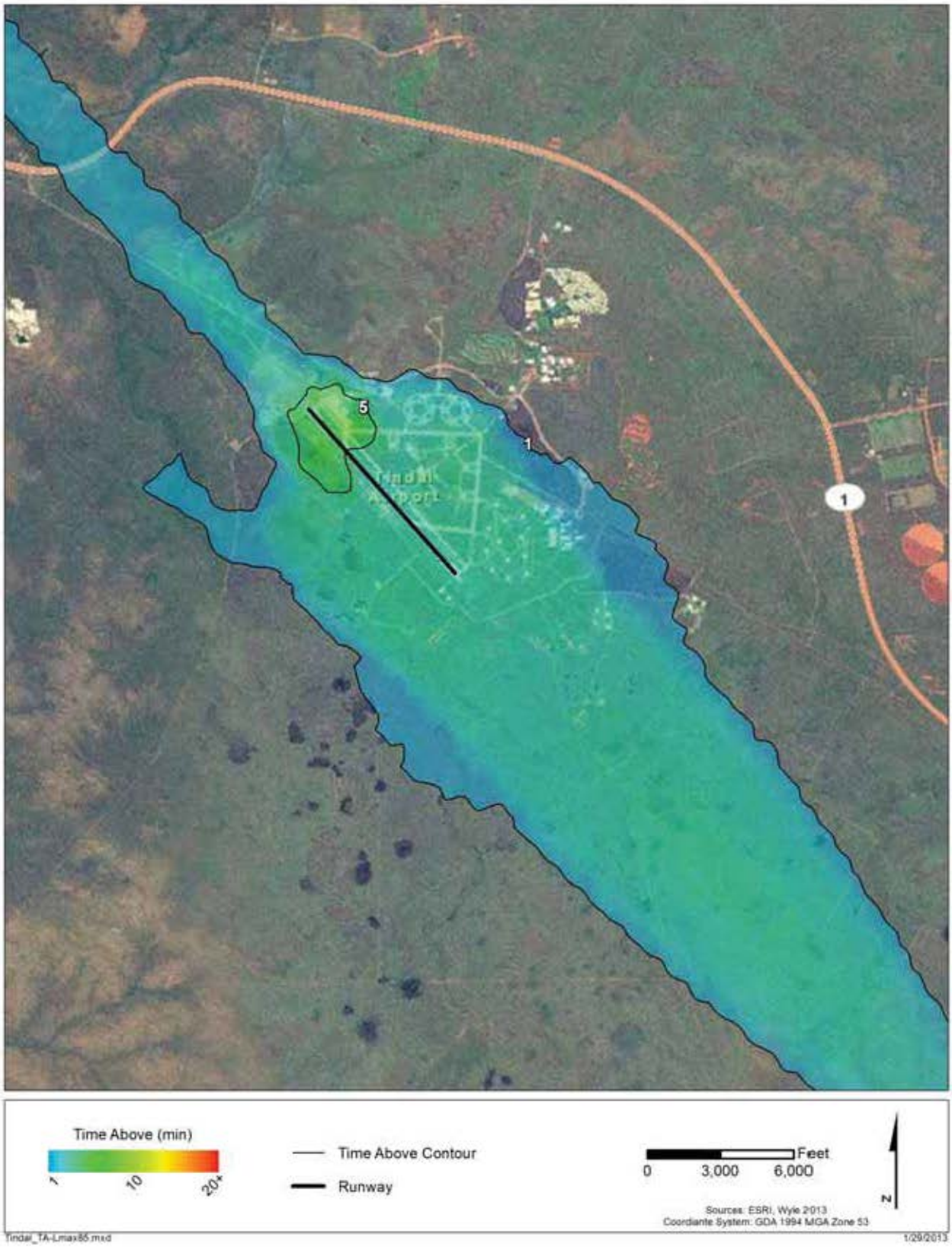

Figure 4-10. TA085 Contours and Gradient for ABD PACAF Aircraft Operations at RAAF Tindal

Figure 4-11. TA100 Contours and Gradient for ABD PACAF Aircraft Operations at RAAF Tindal

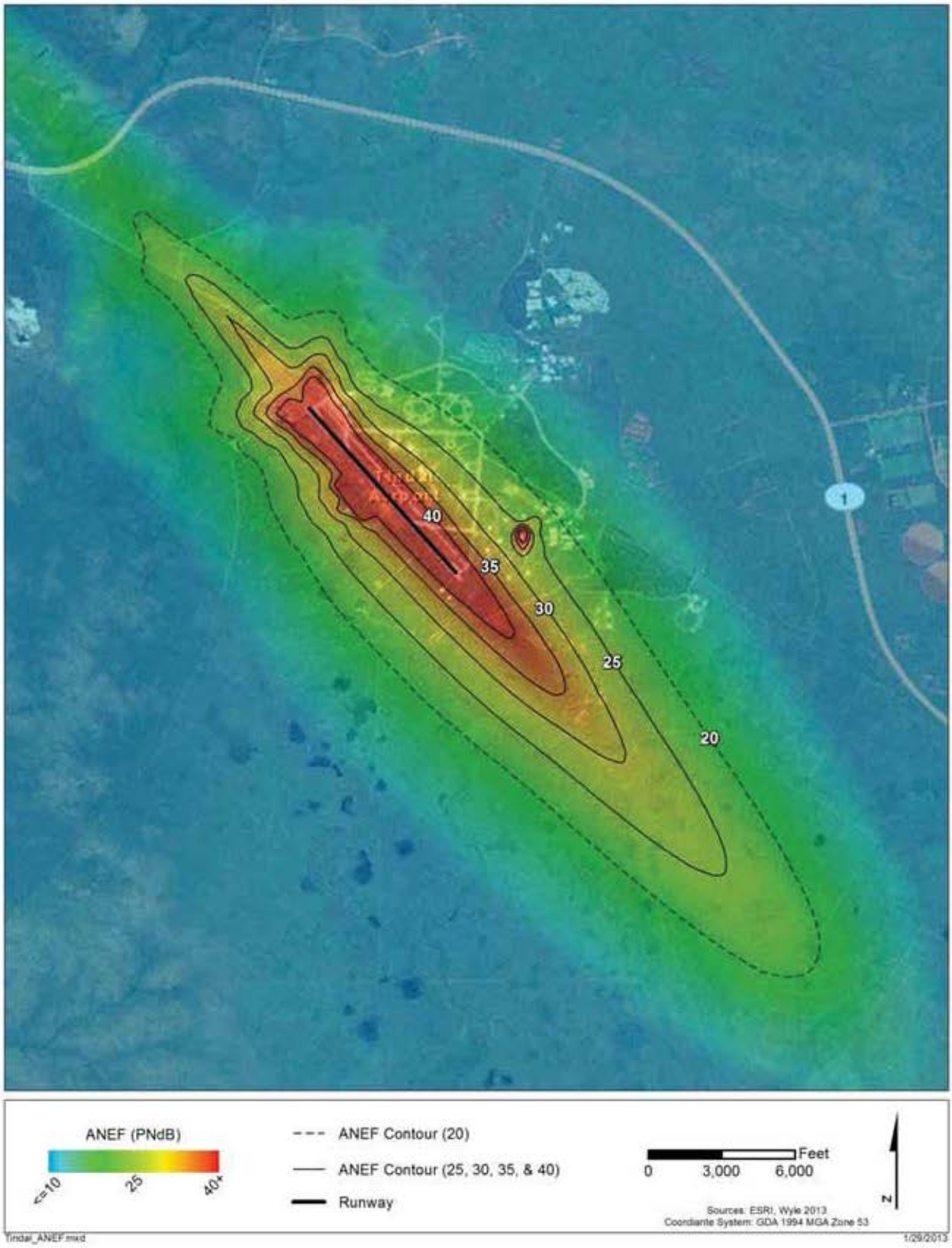

Figure 4-12. ANEC Contours and Gradient for AAD Aircraft Operations at RAAF Tindal

Figure 4-13. Representative Points of Interest for RAAF Tindal

Table 4-4. Noise Exposure for Representative POI for ABD Aircraft Operations at RAAF Tindal

POI		DNL (dB)	Lmax (dB)	NA (events)			TA (minutes)		
ID	Description			70 dB Lmax	85 dB Lmax	100 dB Lmax	70 dB Lmax	85 dB Lmax	100 dB Lmax
TH-1	Katherine Hospital	<45	74	<1	0	0	0.4	0	0
TS-1	St Joseph's College	<45	69	0	0	0	0	0	0
TS-2	Katherine High School	<45	74	<1	0	0	0.2	0	0
TW-1	Anglican Church of Australia	<45	67	0	0	0	0	0	0
TW-2	Heritage Christian Church	<45	79	<1	0	0	0.4	0	0

Table 4-4. Noise Exposure for Representative POI for AAD Aircraft Operations at RAAF Tindal

POI ID	POI Description	DNL (dB)	ANEF (PNdB)
TH-1	Katherine Hospital	<45	0
TS-1	St Joseph's College	<45	0
TS-2	Katherine High School	<45	0
TW-1	Anglican Church of Australia	<45	0
TW-2	Heritage Christian Church	<45	0

References

Australian Bureau of Meteorology (ABM). 2012a. Climate Statistics for Darwin Airport through 8 Nov 2012. http://www.bom.gov.au/climate/averages/tables/cw_014015.shtml. Accessed 12 Nov 2012.

ABM. 2012b. Climate Statistics for RAAF Tindal through 8 Nov 2012. http://www.bom.gov.au/climate/averages/tables/cw_014932.shtml. Accessed 12 Nov 2012.

Batterton 2013a. Electronic mail from Chris Batterton, Wyle, to Joseph J. Czech, Wyle, re: "F-22 flight profiles in Australia", attachment: Fighter Traffic Pattern.pptx., January 9, 2013.

Batterton 2013b. Electronic mail from Chris Batterton, Wyle, to Joseph J. Czech, Wyle, re: "F-22 flight profiles in Australia", attachment: F-22A Climb Profiles noting ETR.xlsx, January 10, 2013.

Czech, Joseph J. and Plotkin, Kenneth J., 1998. NMAP 7.0 User's Manual. Wyle Research Report WR 98-13. Wyle Laboratories Inc., November 1998.

DNWG 2009. Technical Bulletin, Using Supplemental Noise Metrics and Analysis Tools, Department of Defense Noise Working Group, March 2009.

Department of Defense (DoD). 2003. *Sustainment of Ranges and Operating Areas (OPAREAs)*. DoDD 3200.15. Certified Current as of 21 Nov 2003.

Department of Defense (DoD). 2004. *Environmental Effects Abroad of Major Department of Defense Actions*. DoDD 6050.7. Certified Current as of 5 Mar 2004.

FAA 2002. Federal Aviation Administration, Integrated Noise Model (INM) Version 6.0 Technical Manual, FAA-AEE-02-01, January 2002.

Geoscience Australia 2012. © Commonwealth of Australia (Geoscience Australia) 2012. Internet site, http://www.ga.gov.au/. Retrieved December 2012.

DSG 2010. RAAF Base Darwin, Military 2030 ANEC, INM Input Data Report, GHD Pty Ltd for Australian Government Department of Defence, April 2010.

Page, Juliet et al., Advanced Acoustic Model Technical Reference and User Manual. Wyle Report WR 08-12. Wyle Laboratories Inc., February 2012.

Robinson 2012a. Electronic mail from Daniel Robinson, Wyle to Joseph J. Czech, Wyle, re: "Aus trip rpt", attachment: "Australia Site survey Trip Report.docx", December 26, 2012.

Robinson 2012b. Electronic mail from Daniel Robinson, Wyle to Joseph J. Czech, Wyle, re: "Australia baseops files", attachments: "AUS OpsTables.xlsx", "Tindal2012.baseops", Darwin2012.baseops", December 7, 2012.

Wasmer, Fred and Maunsell, Fiona, 2006a. BaseOps 7.3 User's Guide. Wasmer Consulting. 2006.

Wasmer, Fred and Maunsell, Fiona, 2006b. NMPlot 4.955 User's Guide. Wasmer Consulting. 2006.